

TECHNICAL REPORT RD-77-5

AN EXPERIMENTAL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF NOSE MOUNTED CANARD CONFIGURATIONS AT SUPERSONIC MACH NUMBERS (1.5 THROUGH 4.5)

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10 October 1976



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20. ABSTRACT

vapor screen method was used to trace the paths of the vortices shed from the canards. Roll control effectiveness of canards, both with a planar tail and a ring tail was investigated. This test was designated as V41A-C1A.

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INTRODUCTION

In recent years, the Army has developed a strong interest in adding a terminal guidance capability to existing and new missile systems for situations where high accuracy is desired. Nose mounted canard controls are an attractive candidate for terminally guided missiles because of their simplicity and large control force to control package weight ratio.

An accurate method is needed to predict the aerodynamic characteristics of a missile with canards for preliminary design purposes and to help shorten expensive wind tunnel tests in advanced design. Comparisons between results from the prediction method currently used for canard configurations and available wind tunnel data has shown this method is generally inaccurate, particularly for nose mounted canards. This inaccuracy is possibly due to some of the simplifying assumptions, used in developing the theory, being violated by the geometry and conditions of interest.

The purpose of this study is to develop an accurate method of predicting the aerodynamics of canard configurations by developing a systematic set of wind tunnel data for general canard configurations and using this data to improve the currently used aerodynamic prediction technique. A supersonic wind tunnel test was conducted at AEDC on a sting supported model with nose mounted, remotely deflected canards. The primary points of interest in this test were the effect of model roll position, canard size, and canard position on control forces developed. The model was unique in that forces were measured separately on the four

canards, the four tail panels, and the total model, thereby yielding the component forces needed to improve the mathematical model used to predict canard configuration aerodynamics. The vapor screen method was used to trace the paths of the vortices being shed from the canards (Ref. 1). Secondary objectives of this test were to investigate the feasibility of using canards for roll control with both a planar tail and ring tail and to investigate the effect of nose mounted antennas on canard forces. This test extends the Mach number range of a similar transonic test (Ref. 2) and a supersonic test (Ref. 3).

TEST FACILITY

Tunnel A is a continuous, closed-circuit, variable density wind tunnel with an automatically driven flexible-plate nozzle and a 40- by 40-in. test section. The tunnel can be operated at Mach numbers from 1.5 to 6.0 at maximum stagnation pressures from 29 to 200 psia, respectively, and stagnation temperatures up to $750^{\circ}R$ ($M_{\infty}=6.0$). Minimum operating pressures range from about one-tenth to one-twentieth of the maximum at each Mach number. The tunnel is equipped with a model injection system which allows removal of the model from the test section while the tunnel remains in operation. A description of the tunnel and airflow calibration information may be found in Ref. 4.

MODELS

Components of the test configurations are the following:

В	Basic body
Cl	Small canards in aft position
С3	Small canards in forward position
C6	Large "Navy" canards in aft position
N1	Sharp nose
N2	Blunt nose
N4	Prong nose with four antennas
N5	Prong nose with two antennas
N6	Prong nose with no antennas
_T1	Planar tails
TR	Ring tail

Figure 1 shows the Army canard control model as installed in Tunnel A. The baseline model Fig. 2a was a 52-in.-long, 5-in.-diam. tangent ogive cylinder with canards and tail fins. The configuration variables included three noses (Fig. 2b), two tails (Fig. 2c) and three sets of canards (Fig. 2d).

A study of the aerodynamic contributions of the individual model components included testing the sharp (N1) and blunt (N2) noses with the body alone (B). The planar tails (T1, Fig. 2c) and canards (C1, Fig. 2d) were added to BN1 to obtain the baseline model (BN1C1T1). In this configuration, the canard and tail panels are aligned as shown in Fig. 2a.

A similar configuration was tested with the Tl tail section rotated 45 deg. with respect to the rest of the model. The planar tails were maintained at zero attitude (not deflected) and were balance-supported for all configurations throughout the test program.

The "ring tail" (TR, Fig. 2c) was tested in an attempt to obtain better roll control without affecting the stability of the vehicle. As shown in Fig. 2c, the vertical support struts were not attached to the body. With this arrangement, the two horizontal tail balances provided measurements of the total force (but not the moments) on the ring tail. A model fabrication error resulted in an incidence angle of approximately 1 deg. in the pitch attitude of the ring tail relative to the model centerline. Since the model was otherwise symmetrical, this was treated as an incremental model load and accounted for by a coefficient shift included in the data correction procedure.

Two of the three sets of canards (C1 and C3, Fig. 2d) had the same planform area and shape but different attachment angles because of the different longitudinal mounting positions on the model (Fig. 2a). The third set of canards (C6, Fig. 2d) was much larger than C1 and C3 and was tested only with the "prong" nose (N4, N5, N6, Fig. 2b) and the planar tails. All canards were balance supported with provisions for independent deflections (&c) from -5 to 15 deg., produced by remotely operated electric motors internal to the model. The sign convention for the planform surfaces is shown in Fig. 3.

Model base pressures were measured at two positions in the vertical plane equally spaced above and below the model centerline.

INSTRUMENTATION AND PRECISION

The Tunnel A stilling chamber pressure is measured with a 15-, 60-, 150-, or 300-psid transducer referenced to a near vacuum. Based on periodic comparisons with secondary standards, the uncertainty (a bandwidth which includes 95 percent of the residuals) of these transducers is estimated to be within ± 0.2 percent of reading or ± 0.015 psia, whichever is greater. Stilling chamber temperature is measured with a copper-constantan thermocouple with an uncertainty of $\pm 3^{\circ}$ F, based on repeat calibrations.

Base pressures were measured with 15-psid transducers referenced to a near vacuum. These transducers have an estimated uncertainty of ± 0.15 percent of reading or 0.003 psi, whichever is greater.

Main Balance

Model forces and moments were measured with a six-component, moment-type strain-gage balance supplied and calibrated by VKF. Prior to the test, static loads in each plane and combined static loads were applied to the balance to simulate the range of loads and center-of-pressure locations anticipated during the test. The following uncertainties represent the bands of 95 percent of the measured residuals, based on differences between the applied loads and the corresponding values calculated from the balance calibration equations included in the final data reduction. The range of check loads applied and the measurement uncertainties follow.

Component	Balance Design Loads	Calibration Load Range	Range of Check Loads	Measurement Uncertainty
Normal force, 1b*	± 700	± 700	± 175	±1.50
Pitching moment, in1b	±3,645	±3,645	±2,075	±5.00
Side force, 1b*	± 700	± 350	± 100	±0.75
Yawing moment, inlb	±3,645	±1,822	±1,040	±2.00
Rolling moment, inlb	± 320	± 104	± 20	±0.75
Axial force, 1b	0 to 125	0 to 95	0 to 50	±1.00

^{*}About balance forward moment bridge

The transfer distance from the balance forward moment bridge to the model moment reference location was 4.15 in. along the longitudinal axis and was measured with an estimated precision of ± 0.01 in.

Model pitching moments were referenced to a point at model station 26.00 on the centerline of the model (Fig. 2a).

Canard And Tail Balances

Canard and tail panel loads were measured with eight 3-component, moment type, strain-gage balances supplied by USAMC and calibrated by VKF. The same calibration procedure was used with these eight fin balances as was previously described for the main balance. The range of check loads applied and the measurement uncertainties follow.

Component	Balance Design Loads	Calibration Load Range	Range of Check Loads	Measurement Uncertainty
Canard Balances		*		
Normal force, 1b	± 40	± 40	±40	±0.40
Root bending moment, in1b	± 35	± 35	±35 (10)	±0.35
Hinge moment, in1b	± 25	± 25	±10	±0.25
Tail Fin Balances*				
Normal force, 1b	± 60	± 60	±30	±0.60
Root bending moment, inlb	±130	±130	±50	±1.30
Hinge moment, in1b	±100	±100	±35	±1.66

^{*}For the ring-tail (TR) configuration, only the normal-force uncertainty quotations apply to the tail fin balances (Nos. 2 and 4). Reliable moment measurements could not be obtained on the fin balances with this configuration.

The transfer distances from the balance forward moment bridges to the planform reference locations were measured with an estimated precision of ± 0.01 in. and are listed below.

	Forward Moment Bridge to Hinge Line, in.	Balance Centerline to Root Chord, in.
Canard Balance		
No. 1 No. 2 No. 3 No. 4	described for the case ball	wis orevious by
Tail Fin Balance	esimilarayay 2000/970/1657 9	
No. 1 No. 2 No. 3 No. 4	1.12 1.09 1.10 1.12	-0.58 -0.57 -0.57 -0.57
	14	

TEST CONDITIONS AND PROCEDURES

Test Conditions

The test was conducted at Mach numbers 1.5, 2.5, 3.0, and 4.5. The nominal test conditions at each Mach number are given below.

<u>M</u> _∞	p _o , psia	To, °R	q _∞ , psia	p _∞ , psia	Re _k x 10-6
1.5*	nottu 10 bez	560	1.9	1.2	5.4
2.5	15	570	3.8	0.9	11.9
3.0	22	570	3.8	0.6	13.6
4.5	78	600	3.8	0.3	20.8

^{*}Only canard panel loads were measured.

A test summary showing all configurations tested and the variables for each is presented in Table 1.

Test Procedures

After the model was injected into the tunnel, one of three procedures was used to obtain the test data. The first consisted of rotating the model to the desired roll angle and pitching to the maximum negative angle of attack. Each data channel was then recorded at a rate of 60 samples per second as the model was continuously driven to the maximum positive angle of attack at a rate of approximately 0.25 deg. per second. Each calculated data point for this type of operation was based on the average of 16 consecutive samples. These "averaged points" were subsequently interpolated to provide data at precisely the desired angles of attack.

Data obtained in this mode of operation are generally referred to as "continuous sweep" data.

In the second procedure, generally referred to as the "pitch-pause" mode, the model paused at each desired angle in the angle-of-attack sequence and fifty samples of each data channel were recorded. Each data point for this type of operation is the average of these 50 samples.

The third data-taking procedure consisted of pitching the model to a specified angle of attack and taking 50 samples of each data channel at 15-deg. increments of roll angle in the range from 0 to 90 deg.

Periodically during the test, the continuous sweep data were checked by repeating a test sequence in the "pitch-pause" mode. These data agreed within the repeatability listed.

The measured total axial force was corrected to zero base drag using the measured base pressures and the base cross-sectional area. The initial value of base drag (obtained at $\alpha \approx -4$ deg.) was used for all angles of attack in the sweep data because the continuous sweep technique does not allow time for base pressure stabilization. Shortly after the test began it was found that during injection into the free stream, model loads were higher than anticipated. The operating procedure therefore had to be changed so that p_0 was reduced for each injection and retraction, and for many cases at the lowest M_∞ the injection and retraction had to be made at a higher Mach number. This reduced the amount of data which could be obtained during the test entry. Flow-field shadowgraphs and vapor screen photographs were taken at selected test conditions.

DATA REDUCTION

Main balance force and moment data were reduced in both the body and missile (non-rolling body) axis systems. Dimensional quantities employed in the reduction of the main balance data are listed below:

SREF	=	19.635	sq. in.	XMRP	-	26.0	in.
LREF	-	5.0	in.	YMRP	-	0.0	in.
RDFF	-	5.0	in	7MRP		0.0	in

Canard and tail root bending moments are referenced to their respective root chord lines while the hinge moments of the canard and tail are referenced to their hinge lines.

The axis system and sign convention used for the model main balance data is shown in Figure 4; for the canard and tail balances refer to Figures 3 and 5.

A review of the tunnel monitor force and moment data obtained on the various configurations showed evidence of offsets in level due to irregularities in model fabrication and to local nonuniformities in the test section flow. Repeat test runs were made to confirm the cause of the offsets and to establish data reduction procedures to account for the resulting shifts in the levels of the force and moment coefficients. The data consistently indicated the presence of incremental forces acting on localized regions of the model. This produced incremental shifts in the force and moment coefficients, but there was no evidence of a change in the variation of the coefficients with angle of attack. Since the models

with undeflected control surfaces were designed as symmetrical configurations, the extraneous local model loads were accounted for by adding increments to the force and moment coefficients so that they were zero at zero model attitude. The increments established for the symmetrical configurations were used for the corresponding nonsymmetrical configurations that resulted from deflection of the control surfaces. Axial-force coefficients were not shifted.

TEST UNCERTAINTIES

An evaluation of the influence of random measurement errors is presented in this section to provide a measure of the uncertainty of the final test results. Although evaluation of the systematic measurement error (bias) is not included, it should be noted that the instrumentation precision values used in this evaluation represent a total uncertainty including both systematic and random (two standard deviation bandwidth) error contributions.

Test Condition Uncertainty

Uncertainties in the basic tunnel parameters p_0 and T_0 and the two standard deviation uncertainty in Mach number determined from test section flow calibrations were used to estimate uncertainties in the other free-stream properties, using the Taylor series method of error propagation.

rest condition once tainty (1), percent	Test	Condition	Uncertainty	(±).	percent
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M _∞	M	Po	To	P _∞	q _∞	Re
1.5	1.3	0.2	0.5	2.9	0.3	0.8
2.5	0.8	0.2	0.5	3.0	1.5	1.3
3.0	0.7	0.2	0.5	3.0	1.7	1.3
4.5	0.4	0.2	0.5	2.5	1.6	1.3

Test Data Uncertainty

The main balance force and moment data are presented in the missileaxis system with pitching moments referenced to the midpoint of the model length (MS 26.00).

The balance and base pressure uncertainties were combined with uncertainties in the tunnel parameters, using the Taylor series method of error propagation, to estimate the uncertainties of the aerodynamic coefficients presented below.

Measured Coefficient Uncertainty

		(±), per	cent	
M _{co}	CN	C _m	Ce	CA
2.5	1.70	1.72	•	4.31
3.0	1.91	2.24	Dan S. b.,	2.72
4.5	1.80	2.96	E par covere	4.63

^{*}For these cases, the corresponding repeatability values listed below are to be used since the maximum rolling-moment coefficients are approximately equal to balance precision.

The uncertainties of the aerodynamic coefficients were also computed using only the balance and base pressure uncertainties and the nominal test conditions. This calculation is based on the assumption that the free-stream flow nonuniformities introduce a bias type of uncertainty that is constant for all test runs at a particular Mach number. The values therefore represent the data repeatability expected and are especially useful for detailed discrimination purposes in parametric model studies.

	Measure	d Coefficient	Repeatability	(±)
M _∞	C _N		C _e	C _A
2.5	0.020	0.021	0.002	0.017
3.0	0.020	0.022	0.002	0.015
4.5	0.020	0.022	0.002	0.014

The uncertainty in model angle of attack and roll, as determined from tunnel sector calibrations and possible errors in model deflection calculations, is estimated to be ± 0.1 deg.

REFERENCES

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- Burt, J. R., Jr. "An Experimental Investigation of the Aerodynamic Characteristics of Several Nose Mounted Canard Configurations at Transonic Mach Numbers." Technical Report RD-75-2, 30 August 1974.

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- Test Facilities Handbook (Tenth Edition). "von Kármán Gas Dynamics
 Facility, Vol. 3." Arnold Engineering Development Center, May 1974.
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NOMENCLATURE

SYMBOL	MNEMONIC	DEFINITION
a eles partipasse	ALPHA	total pitch plane angle of attack, deg.
Фс	PHICND	total model roll angle, deg.
ФΤ	PHITAL	tail roll angle relative to canard, deg.
⁶ C1,2,3,4	DCND1,2,3,4	canard deflection relative to missile centerline, deg.
C _{NNR}	CNP	total model normal force coefficient, N/QSREF, non-rolling axis system
C _m NR	CLMP	total model pitching moment coefficient, M/QSREFLREF, non-rolling axis system
C _{NT1,2,3,4}	CNT1,2,3,4	tail panel normal force coefficient, NT/QSREF
C _{NC1,2,3,4}	CNC1,2,3,4	canard panel normal force coefficient, NC/QSREF
C _{HM} _{C1,2,3,4}	CLMHC1,2,3,4	canard hinge moment coefficient, MHC/QSREFLREF

NOMENCLATURE (Continued)

SYMBOL	MNEMONIC	DEFINITION
CBMC1,2,3,4	CLMRC1,2,3,4	canard root bending moment coefficient, MBC/QSREFLREF
Ce	CBL	model rolling moment coefficient, LB/QSREFBREF, non-rolling axis system or missile axis system
CA	CA	model forebody axial force coefficient, FA/QSREF, non-rolling axis system and missile axis system
C _{HMT1,2,3,4}	CLMHT1,2,3,4	tail hinge moment coefficient, MHT/QSREFLREF
C _{BMT1,2,3,4}	CLMRT1,2,3,4	tail root bending moment coefficient, MBT/QSREFLREF
CYNR	СҮР	total model side force coefficient, Y/SREF, non-rolling axis system
c _{nNR}	CYNP	total model yawing moment coefficient, NB/QSREFBREF, non-rolling axis system
Q _∞	Q	dynamic pressure, psia
Sref	SREF	non-dimensionalizing reference area, sq. in.
^l ref	LREF	non-dimensionalizing reference length, in.
^b ref	BREF	non-dimensionalizing reference length, in.
N	N -100 +1502017	total normal force on model, 1bs.
Mm	M	total pitching moment on model, inlbs.
N _T	NT	normal force on tail panel, lbs.
N _C	NC	normal force on canard, lbs.
HMc	MHC	canard hinge moment, inlbs.
BM _C	MBC	canard root bending moment, inlbs.
Me	LB	total model rolling moment about body/ missile axes, inlbs.

NOMENCLATURE (Concluded)

SYMBOL	MNEMONIC	DEFINITION
A	FA	model forebody axial force, lbs.
HMT	MHT	tail panel hinge moment, inlbs.
BM _T	MBT	tail panel root bending moment, inlbs.
Y	Y	model side force, lbs.
M _n	NB	model yawing moment about body/missile axes, inlbs.
M, M _∞	MACH MRP	free stream Mach number moment reference point
Po		stilling chamber total pressure, psia.
T _o		stilling chamber total temperature, deg. Rankine
P∞		free stream static pressure, psia
Re _£	RN/L	free stream Reynolds number, 1/ft.
MS		missile station, in.
Ab		missile base area
V		free stream velocity, ft./sec.
CPXC		canard panel center of pressure relative to hinge line, in.
CPXT		tail panel center of pressure relative to hinge line, in.
CPYC		canard panel center of pressure relative to root chord, in.
CPYT	,	tail panel center of pressure relative to root chord, in.
b _C (x)		distance from canard hinge line to MRP, in.
b _T (x)		distance from tail hinge line to MRP, in.

									TE	EST	RUN	NUM	B	S								10	01	0	9	IDV
			4.5	17	73	74						200		J.G	140				83	76	82				1	(2) N
		BERS	3.0	174	232	233	991	191	165	164	163	162	172	167	171	170	691	168	139	134		ALPHA	ALPHA,	AL PHA	ALPHA,	IDVAR(2) NDV
	-76	MACH NUMBERS	2.5		10	13			ode	11.33	Cy									157			-		-	
	08-25-76	MAC	1.5	T T	3.2	GRN0						- 5					Tel					MACH	MACH	MACH	MACH	IDVAR(1)
	DATE:	Oi oi	RUNS	2	-	1	1	H		la i a								•	2	3	1			a.		
			ik.				n:si		Set 1		T de						fi					CNC4	5	CYNP ,	-	
	ARY				100			0 5/8 0 5/8	(1) (1)								108	A S				NC3	CBL	СУР		
	SUMM																					٥.		-	-	
	DATA SET/RUN NUMBER COLLATION SUMMARY	PARAMETERS/VALUES																				CNC2	CLMRC4	CLMRT4		
	COLL	ETERS/	φŢ	OFF	0	0	OFF.	F										-	0	0	0		RC3	RT3		ts
ABLE 1.	BER	ARAM	δC4	-	OFF	OFF	-3	0	3	9	6	15	-3	0	3	9	6	15	-3	0	-	CNC	CLMRC3	CLMRT3		Coefficients → 90°
¥-	Š	۵	δC3	OFF.	OFF.	OFF	0	1				4	-3	0	3	9	6	15	0	H	•		C2	T2		Coeffi 0° + 90°
	N. N.		§€2 k	OFF (OFF	OFF	-3	0	3	9	6	15	-3	0	3	9	6	15	-3	0	-	CNT4	CLMRC2	CLMRT2	CBL	ئ ن ک
	SET		\$C1 (OFF	OFF	OFF	0	H				-	-3	0	8	9	6	15	0	F			5	=		:
	ATA		φc	0	0	45	0	-	F	100		-	45	F				-	0	F	-	CNT3	CLMRCI	CLMRT1	CYNP	φc(A):
		SCHD.																				1	1	1	1	
	\Box	Š	8	A																		CNT2	CLMHC4	CLMHT4	CYP	
			N O																						-	, 3°
	-C1A		CONFIGURATION									0.5								1		CNT	CLMHC3	, CLMHT3	5	+ +
	AEDC V41A-C1A		CON	BNJ	BNITI	BNITI	BNICI	-		. 93								-	BNICITI		-	Ь	HC2	CLMHT2	Ь	
	AEDC	-	ď	_	_	_	_	-							-				-			CLMP	CLM	CLN.	CLMP	α(A):
	27:	DATA SET	DENTIFIER	RXH001	1 002	003	004	900	900	000	800	600	010	110	012	013	014	015	910	017	018		CLMHC1	CLMHT1		
	TEST	ò	IDE	RX																		_	-	Ü	CNP	
												2	24									8=A:	R=B:	R=C:	R=D:	

TABLE 1. (Continued)

DATA SET	אבתה ולוע-כוע		DAT	A SET	/RUN	NUMBI	ER COL	DATA SET/RUN NUMBER COLLATION SUMMARY	MMARY	DATE	: 08-25-76		
		SCHD				PAR	AMETER	PARAMETERS/VALUES		NO.	L	MACH NUMBERS	
DENTIFIER	CONFIGURATION	ð	φc	§C1	8C2 8C3		4 47			RUNS	1.5	3.0	4.5
RXH019 B	BNICITI	A	0	0	3	0	3 0			2		138	81
020		T	1	H	9		19					137	80
120					6		6					136	79
022				•	15	15	2			-		135	78
023			0	-3	m	3 -3	3			'n	158	140	84
024			H	0.5	-0.5 -0	-0.5 0	0.5			-			82
025	•			l	-1	-	-			-			98
970				2	-2 -2		2			3	159	141	87 28
027			1	5	-5 -5		5			3	160	142	88
820			45	-3	-3 -	3 -3	3			2		148	96
620				0	0	0	0					143	68
030				3	3	3	3					147	94
031				9	9	9	9					146	93
032				6	6	6	6		1/2-1			145	92
033	À		•	15	15 15	5 15	9					144	16
034 BI	BN1C1T1		0	0	-3 (0 -3	3 45			4		124	105
035			0	0	0	0	0 45			3	911	118	86
036			0	0	_	0	45			-			104
	, CNT1	CNT2	CNT3	_	CNT4	+	CNC1	CNC2	CNC3	CNC4	, MACH	ALPHA	01,
	CLMHC3	CLMHC4	CLMRC	C1	CLMRC		CLMRC3	CLMRC4	CBL	CA	, MACH	ALPHA	10
CLMHT1 CLMHT2	, CLMHT3	, CLMHT4	CLMRTI	IT1	CLMRT2		CLMRT3	, CLMRT4	CYP	, CYNP	MACH	ALPHA,	01,
CLMP	A)	CYP	CYNP		CBL					,	MACH	, ALPHA	9
	A STANTON				Coe	Coefficients	ents	E 1601 L	A SEPTEMENT		IDVAR(1)	IDVAR	IDVAR(2) NDV
α(A):	-5° + 13°		φc(φc(A):	00 + 00	°06							

TABLE 1. (Continued)

\prod	-	1									\neg	BIR							T		10	2	,10	9	NDV
	L	4.5	103	102	101	100	114	113	106	112	Ξ	130	109	108							A	A	A		R(2)
MAFRA	UMBERS	3.0	123	122	121	120		132	126		131	130	129	128	234	239	238	237	236	235	ALPHA	ALPH	, ALPHA	, ALPHA	IDVAR(2)
SERVIN HOAM		.5 2.5																			MACH	MACH	MACH	MACH	IDVAR(1)
		RUNS	2			•	-	2	2	-	2			-	-						CNC4	1	CYNP		
MAKY																					CNC3	1	CYP		
DATA SET/RUN NUMBER COLLATION SUMMARY	VALUES																				CNC2	CLMRC4	CLMRT4		
ER COLL	# -	4 61	3 45	6 ⊤	9	15	5	-3	0	1	3	9	9	5	0 0	1	3	9	6	15	CNC1	CLMRC3	CLMRT3		ients
NOWB		δC3 δC4	0	0	0	. 0	-5	-3	0	1	3	9	6	15	0	H					+	•		•	Coefficients
/RUN		δC2 δ	3	9	6	15	-5	-3	0	-	3	9	6	15	0	-	3	9	6	15	CNT4	CLMRC2	CLMRT2	EB.	3
AIA SE	Т	\$C 2C1	0 0	0 0	0 0	0 0	45 5	T -3	0	•	3	9	6	15	0 0					4	CNT3	LMRC1	CLMRT1	CYNP	
	SCHD.	0	A				8	A	F						A						CNT2 (HT4		
	RATION																					TO ECHINICO	CLMHT3 , CL	A CYP	
	CONFIGURATION		BNICITI											•	BN1C3T1	H						7.5	CLMHT2 , CL	CLMP CA	
	DATA SET	DENTIFIER	RXH037	038	039	040	041	042	043	044	045	046	047	048	046	020	051	052	053	. 054		CLMHC1 C	CLMHT1 C	CNP	

ABLE 1. (Continued)

CONTACTOR SET CONFIGURATION CONFIGURATIO	TEST		AEDC V41A-C1A	4-CIA		DAT	A SE	T/RUN	NON	IBER I	100	ATION SI	IMMARY	DA	DATE: 0	08-25-76	9	
RXH055 BN1C3T1 B 0 5 -5 5 5 0 0 1 1 5 2.5 5 1 1 1 1 5 2.5 5 1 1 1 1 5 2.5 5 1 1 1 5 2.5 5 1 1 1 1 5 2.5 5 1 1 1 1 1 1 1 1	2	TASET			JH JY			2	1	ARAME	TERS/	VALUES		-	02	MACH	NUMBERS	
Name San Carrell	IDEN	TIFIER	CON	FIGURATION	8	+	128			8C4	4		F	4	7-		5 3.0	4.5
1056	RXH	1055	BN1C3	T1	B	0	2	100		-	0				-	-	-	
057 068	Н	056			8	0	2	-2	-2	2	H						241	
058		057			В	0	-3	3	3	-3							240	
059		950			A	45	0	0	0	0							243	
060 BNZ 1 0 0 0 0 0 0 0 0 0		650	•		A	45	15		15	15	-				-		244	
061 BNZCITI A 0 0 3 0 -3 0 <th< td=""><td></td><td>090</td><td>BN2</td><td></td><td>A</td><td>0</td><td>OFF</td><td></td><td></td><td></td><td>)FF</td><td></td><td></td><td></td><td>2</td><td></td><td>175</td><td>69</td></th<>		090	BN2		A	0	OFF)FF				2		175	69
062		190	BN2CT	III	А	0	0	-3	0	-3	0				-		156	
063 963 9 3 3 9 <td></td> <td>790</td> <td></td> <td></td> <td>E</td> <td></td> <td></td> <td>0</td> <td>H</td> <td>0</td> <td>H</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>150</td> <td></td>		790			E			0	H	0	H						150	
064 065		063						3		3							155	
065 ▼ ▼ ▼ ▼ 15 ▼ 15 □ <td></td> <td>064</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>9</td> <td></td> <td>9</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>154</td> <td></td>		064						9		9							154	
066 Particular Particular <td></td> <td>990</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>6</td> <td></td> <td>6</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>153</td> <td></td>		990						6		6							153	
068 BN4C6T1 A 0 0 0 0 0 1 2 211 210 2		990	•		-	-	-	15	-	15					1		152	
069 9 9 9 9 9 209 209 209 209 209 209 209 209 209 209 209 209 209 209 200		290	BN4C6	ITI	A	0	0	0	0	0							199	
069 9 9 9 9 9 15 7 209 7 208 7 208 7 208 7 208 7 208 7 208 7 208 7 1 7 208 7 1 7 208 7 7 208 7 1 7 208 7 1 7 208 7 1 7 208 7 1 7 1 7 1 7 1 7 1 7 1 7 1 7 1 7 1		890			E		+	3	H	3					1210	0	202	
O70		690						6		6					205	6	207	
O71 ▼ 072 ▼ 072 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		070				^	1	15	•	15					208	3	200	
CNP CLMP CNT1 CNT2 CNT3 CNT4 CNC1 CNC2 CNC3 CNC4 MACH CLMHC1 CLMHC2 CLMRC1 CLMRC4 CLMRC4 CLMRC4 CR CA MACH CLMHT1 CLMHT3 CLMHT4 CLMRT1 CLMRT3 CLMRT4 CYNP MACH CNP CYP CYNP CBL MACH MACH CNP CYP CYNP CBL MACH CNP CAP CYNP COPEFFICIENTS IDVAR(1)		170				100		6	0	6					-		201	
CNP CLMP CNT1 CNT2 CNT3 CNT4 CNC1 CNC2 CNC3 CNC4 MACH CLMHC1 CLMHC2 CLMHC3 CLMHC4 CLMRC1 CLMRC3 CLMRC4 CBL CYP CYNP CMP CBL CMP CNP COPFFICIENTS COPFFIC			•		A	45		0	0	0				-		-	203	
CLMHC1 CLMHC2 CLMHC3 CLMHC4 CLMRC1 CLMRC3 CLMRC4 CBL CA MACH CLMHT1 CLMHT2 CLMHT3 CLMHT4 CLMRT1 CLMRT2 CLMRT3 CLMRT4 CYP CYNP MACH CNP CLMP CA CYNP CBL COMP CBL IDVAR(1)			CLMP	CNT1	, CNT2	CNT	3	CNT		CNC	1	CNC2	CNC3	CNC4		CH	ALPHA	10
CLMHT1 CLMHT2 ,CLMHT3 ,CLMHT4 ,CLMRT1 ,CLMRT3 ,CLMRT4 ,CYP ,CYNP ,MACH ,CNP ,CNP ,CBL ,CNP ,CNP ,CNP ,CNP ,CNP ,CNP ,CNP ,CNP	_	_]	CLMHC2	CLMHC3	CLMHC4	CLM	RCI	CLM	RC2	CLMR	C3	CLMRC4	CBL	CA	, MA	CH	, ALPHA	01
CNP CLMP CA CYNP CBL , , MACH , CDL COefficients , , , MACH , CDL COefficients , , , , , , , , , , , , , , , , , , ,	_		CLMHT2	, CLMHT3	, CLMHT4	CLM	RTI	CLM	RT2 .	CLMR	T3	CLMRT4	CYP	, CYNP		ЮН	ALPHA,	01
I DVAR(1)		٥.	CLMP	, ca	, CYP	CYN	0	CBL,							M.	ICH	, ALPHA	9 '
								3	Jeffi	cient	S		Self-reserved to the		H	VAR(1)	IDVAR(2)	(2) NDV

At M_{∞} = 1.5 the nose shock reflection crossed the model near the base, and tests were made only to obtain canard panel loading. NOTE:

-5° + 5°

		_						7.6	ST	RUN	NUN	BER	s	llege.							9	2	2	9	NDV
	MBERS	3.0 4.5	902	205	204	161	194	193	192		361	198	197	196	183	182	181	180	184	187	1	ALPHA	ALPHA ,	, ALPHA	IDVAR(2)
08-25-76	MACH NUMBERS	2.5											3			3	7	9				H H	CH	MACH	IDVAR(1)
	L	1.5	215	214	213	216	220	219	218	217	221	224	223	222	225	228	227	226	229	231	, MACH	MACH	, MACH	MA	ID
DATE	ON	RUNS	2						-	-	2	-									CNC4	8	CYNP		
MMARY																					CNC3	- B	CYP		
DATA SET/RUN NUMBER COLLATION SUMMARY	PARAMETERS/VALUES																				CNC2	CLMRC4	CLMRT4		
R COLLATIC	TERS/	4	0	H																		3	RT3		ts
BER	ARAME	δC4	3	6	15	0	3	6	15	15	0	3	6	15	0	3	6	15	0	9	CNC	CLMRC3	CLMRT3		cien
RUN NUN		δC3	3	6	15	0	H		4	15	0	3	6	15	0	t		•	0	9	14	CL MRC2	CLMRT2		Coefficients
1/R		δC2	3	6	15	0	- 3	6	15	15	0	3	6	15	0	3	6	15	0	9	CNT4	ರ	ರ	CBL.	
TA SE		\§C1	5 3	9	5 15	0				15	0 9	3	6	15	0				9	9 9	T3	CLMRC1	CLMRT1	d.	
DA	-	φc	45	45	45	_	-				45			1	_				45	45	CNT3	5	73.	CYNP	-
H	SCHD	8	A	E		A	E							•	Y.						CNT2	CLMHC4	CLMHT4	CYP	
-C1A		CONFIGURATION	TT			ITI									ITS						CNTI	CLMHC3	CLMHT3	2	
AEDC V41A-C1A			BN4C6T1			BN5C6T1								•	BN6C6T1						CLMP	CLMHC2	CLMHT2	CLMP	
rest: A	DATA SET	IDENTIFIER	RXH073	1074	075	9/0	770	8/0	620	080	180	085	083	084	085	980	087	088	680	060		CLMHC1	CLMHT1 .	CNP	

a(B): -5° + 5°

NOTE: At M_{ω} = 1.5 the nose shock reflection crossed the model near the base, and tests were made only to obtain canard panel loading.

TABLE 1. (Continued)

								TE	EST	RUN	NUM	BEF	s				BY.			10	0	0	9
		4.5			2	9	2	4	8	1				29	62	14	12	=	90				
	ABERS	3.0	186	188																AL PHA	ALPHA	ALPHA	ALPHA
9/-0	MACH NUMBERS	2.5			91	20	19	18	46	12	42	41	28	09	19	99	54	53	25	1			
0/-52-80	MA	1.5	230																	MACH	MACH	MACH	MACH
חשוב.	o'i	RUNS	2	-	2	_				1	_		1	2						7 -			
		u.																		CNCA	2	, CYNP	
MARY																				CNC3	CBL	СУР	
N SUM	S		E7 .																		C4 .		•
DATA SET/RUN NUMBER COLLATION SUMMARY	PARAMETERS/VALUES																			CNC2	, CLMRC4	, CLMRT4	
0 0 1	ETERS	Τφ	0	L															•	_	CLMRC3	CLMRT3	
MBER	PARAM	δC4	15	0	0	3	6	15	2	2	0	0				0	3	6	15	CNC	CLV.	, CLI	
DN N		δC3	15	0	0			>	-5	-2	0	0			•	0	3	6	15] .	CLMRC2	CLMRT2	
L'RU		δC2	15	0	0	က	6	15	-5	-2	0	0			-	0	က	6	15	CNT4	J.	J.	8
SE.		δC1	15	0	0			-	2	2	0	0			1	0	3	6	15		[2]	E	
DAT		οφ	45	180	0										•	45			1	CNT3	CLMRC	CLMRT	CYNP
	SCHD.	8	A	A	A				B	8	8	A	A	A	A	A			1		MHC4	MHT4	
٦	T																			CNT2	CLM	CLMH	CYP
Y I	10124010	CONFIGURATION	u	U	rR	1														CNT1	CLMHC3	, CLMHT3	S
MEDC V41A-CIA			BN6C6T	BN6C6T	BNICITR														•	CLMP	CLMHC2	CLMHT2	CLMP
ESI:	DATA SET	IDENTIFIER	RXH091	7092	093	094	960	960	260	860	060	100	101	102	103	104	105	106	107	CNP		CLMHT1	CNP

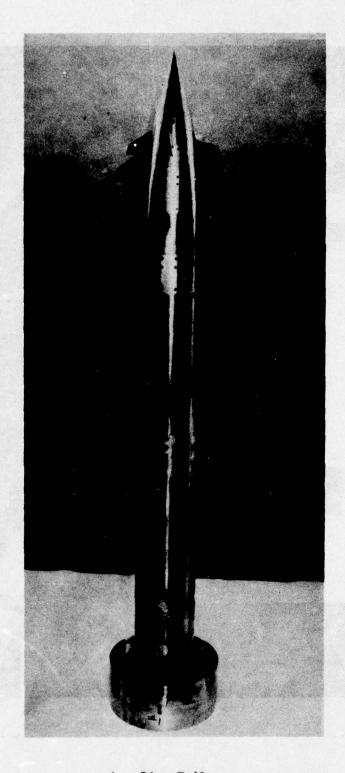
 $\alpha(A): -5^{\circ} + 13^{\circ}$ $\phi_{C}(A): 0^{\circ} + 90^{\circ}$ $\alpha(B): -5^{\circ} + 5^{\circ}$ $\omega(B): -5^{\circ} + 5^{\circ}$ NOTE: At M = 1.5 the nose shock reflection crossed the model near the base, and tests were made only to obtain canard panel loading.

TABLE 1. (Concluded)

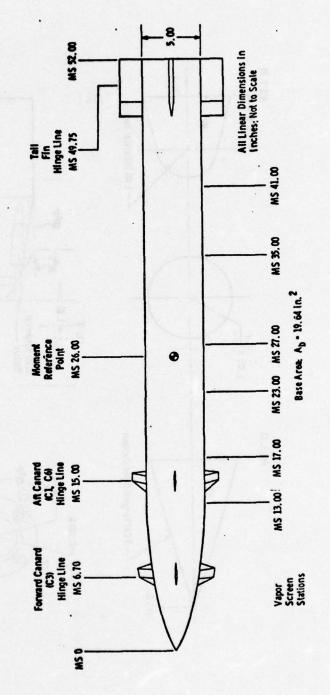
EST: AE	AEDC V41A-C1A	CIA	٦	DATA	SET	RUN N	UMBER (DATA SET/RUN NUMBER COLLATION SUMMARY	NO SUM	MARY	DAIE	0/-52-80		
DATA SET			SCHD.				PARAME	PARAMETERS/VALUES	UES		OL		MACH NUMBERS	
DENTIFIER	CONFI	CONFIGURATION	ο _φ	8	§C1	δC2 δC3		фТ			RUNS	1.5	2.5 3.0 4.5	7
RXH108	BNICITR	R	A	9	0	0 0	0	0					47	
109			A	12	0	0 0	0	0				7	48	
110			A	16	0	15 0	15	0			1		49	
111	•		A	12	0	15 0	15	0					20	
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٦	CLMP	CNT	CNT2	CNT3		CNT4	CNC.	, CNC2		CNC3	· CNC4	MACH	PHICND	= =
CLMHC1	2	2	CLMHC4	CLMRCI	[2]	CLMRC2	1 .	1	CLMRC4	CBL	2	MACH	, PHICND	2
CLMHT1 C	2	CLMHT3	CLMHT4	CLMRT1	IT.	CLMRT2	CLMRT3	-	CLMRT4	CYP	CYNP	MACH	, PHICND	10
CNP	CLMP	5	CYP	CYNP		CBL						MACH		9 1
						Coef	Coefficients	S				IDVAR(1) IDVAR(2) NDV	NDV
8	a(A): -5	-5° + 13°		φc(φc(A):	06 + 00	.00							



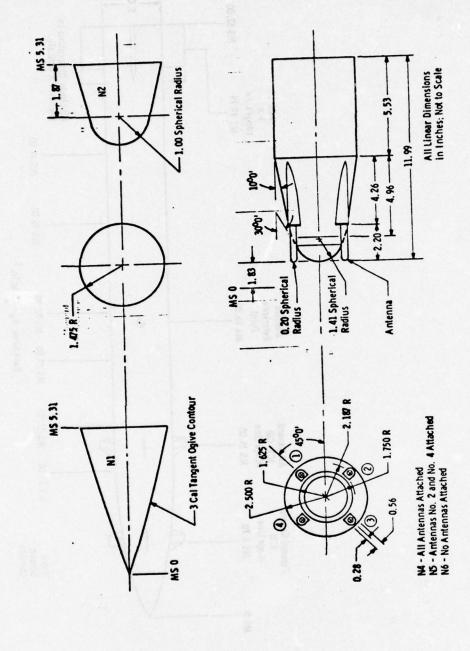
a. Model Set-up in Tunnel "A" Figure 1. Model Photographs



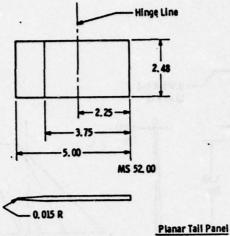
b. Ring Tail Figure 1. Concluded

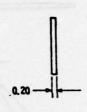


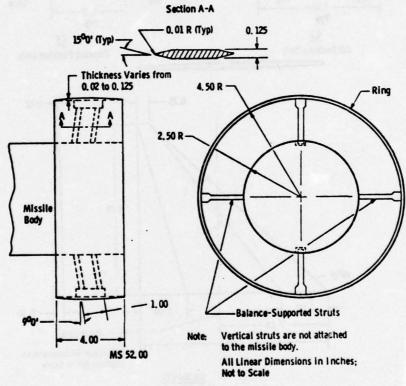
a. Canard, Tail, and Vapor Screen Stations Figure 2. Model Details



b. Details of Various NosesFigure 2. Continued

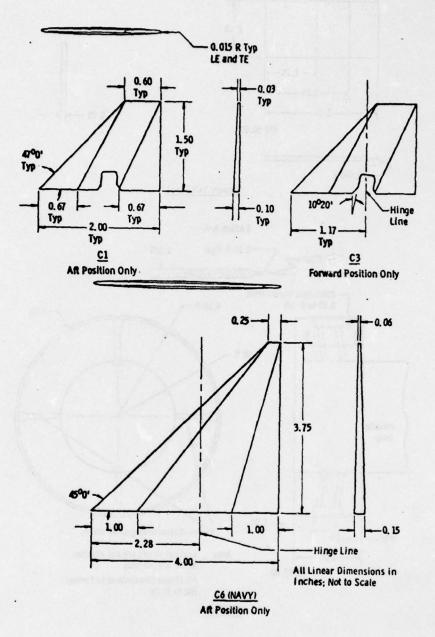




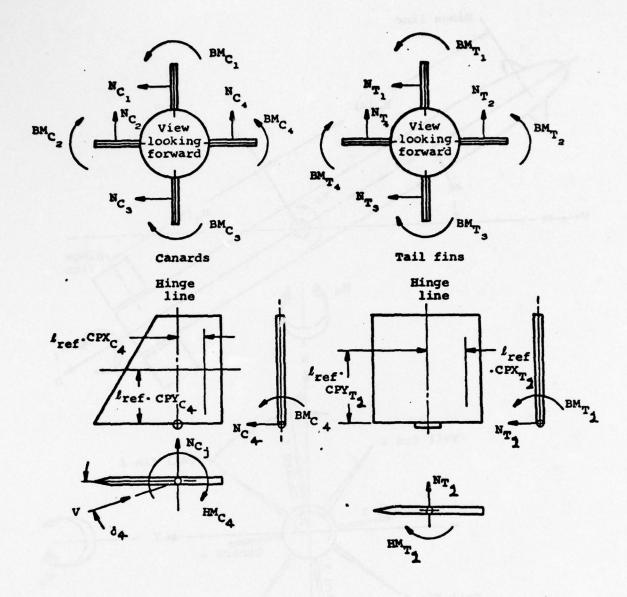


Ring Tall

c. Planar Tail Panel and Ring Tail Panel Figure 2. Continued



d. Canards C1, C3, and C6 Figure 2. Concluded



- Note 1: Normal forces are measured perpendicular to the panel platform.
- Note 2: Tail panels are numbered clockwise and canard panels counterclockwise.

Figure 3. Axis Systems and Positive Sign Convention; Canards and Tail Fins

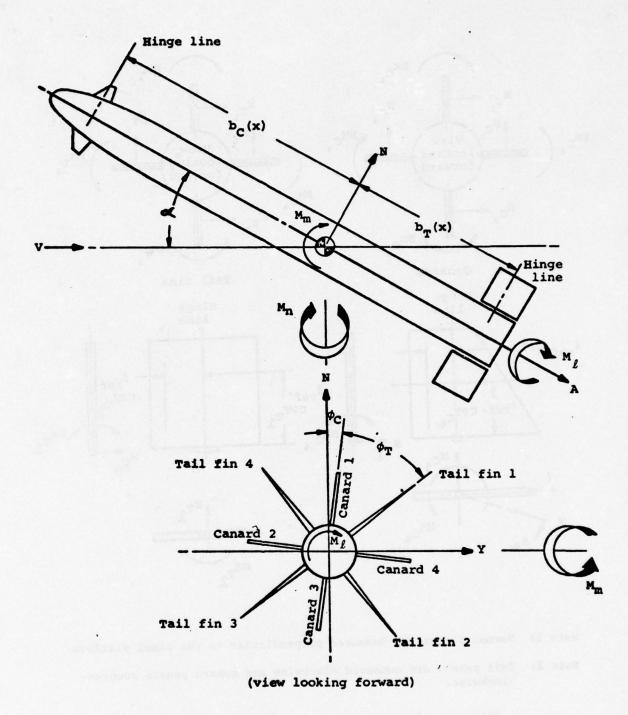
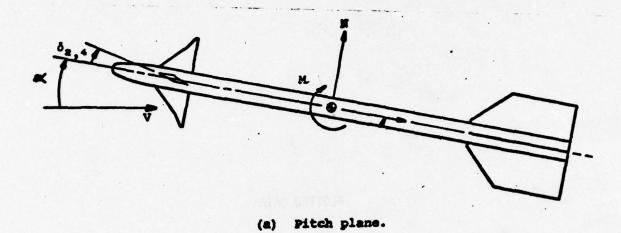


Figure 4. Axis Systems and Positive Sign Convention; Unrolled Body Axis System



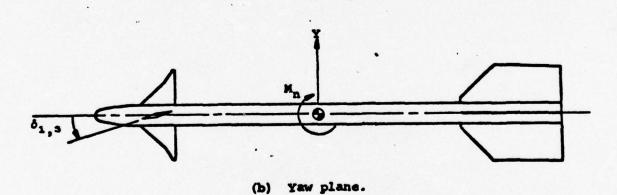
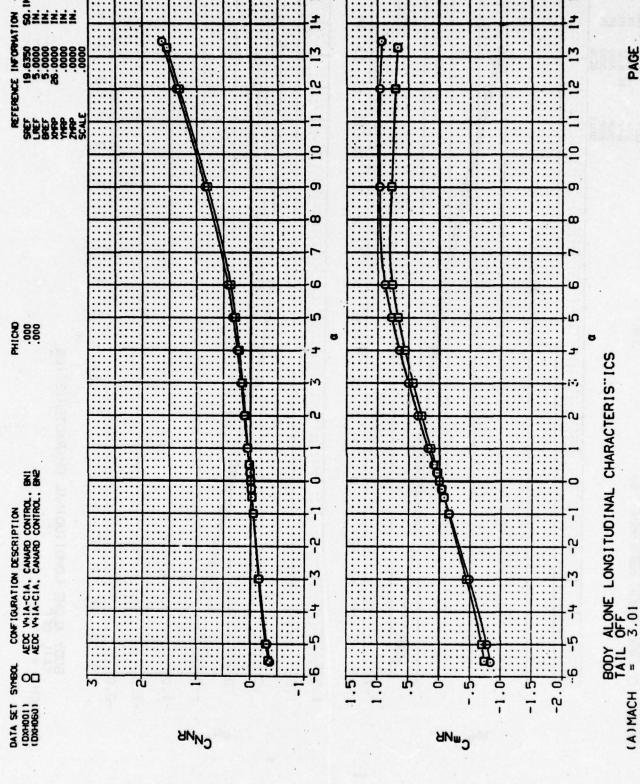
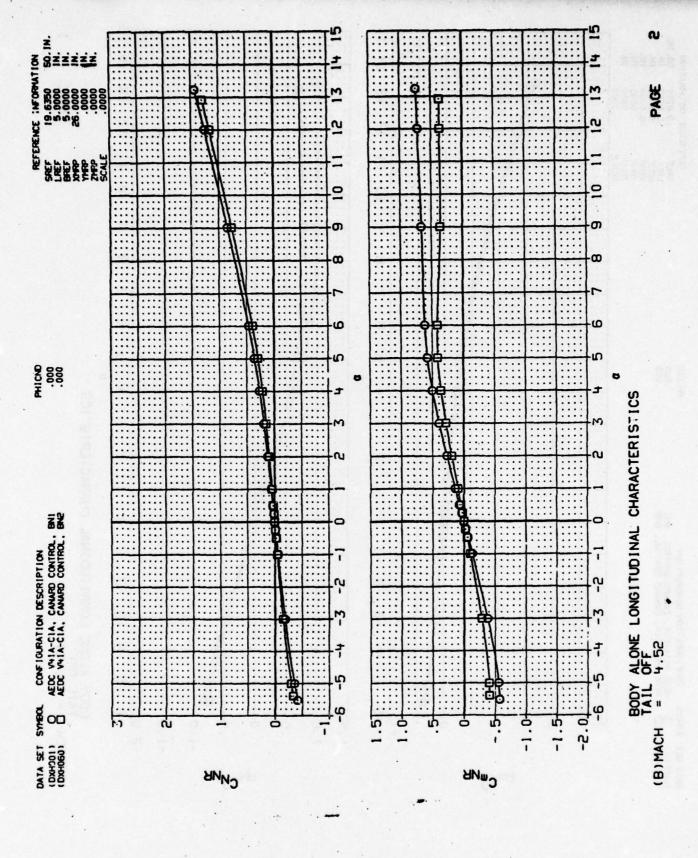


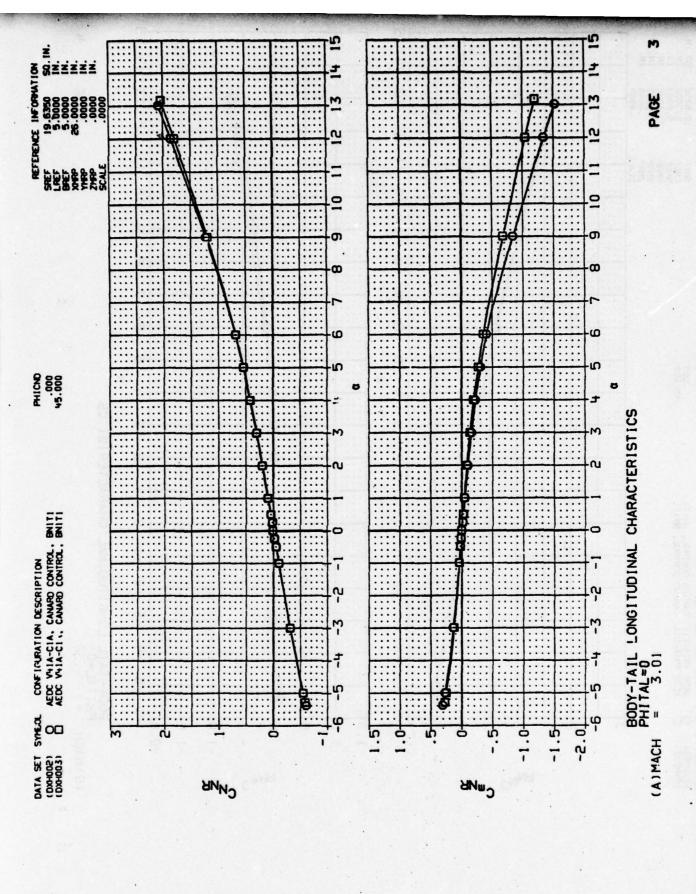
Figure 5. Sign Convention for Canard Deflection Angles

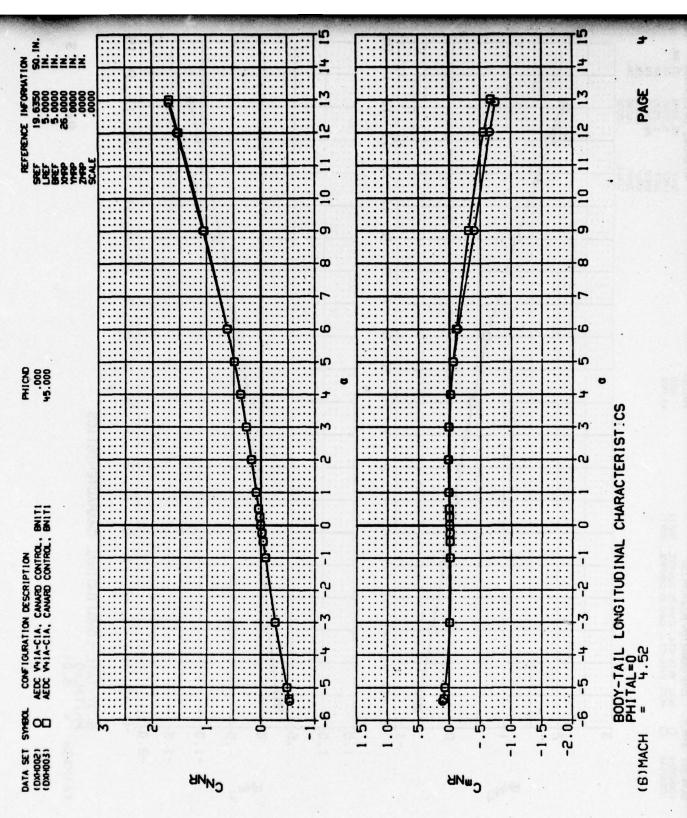
PLOTTED DATA

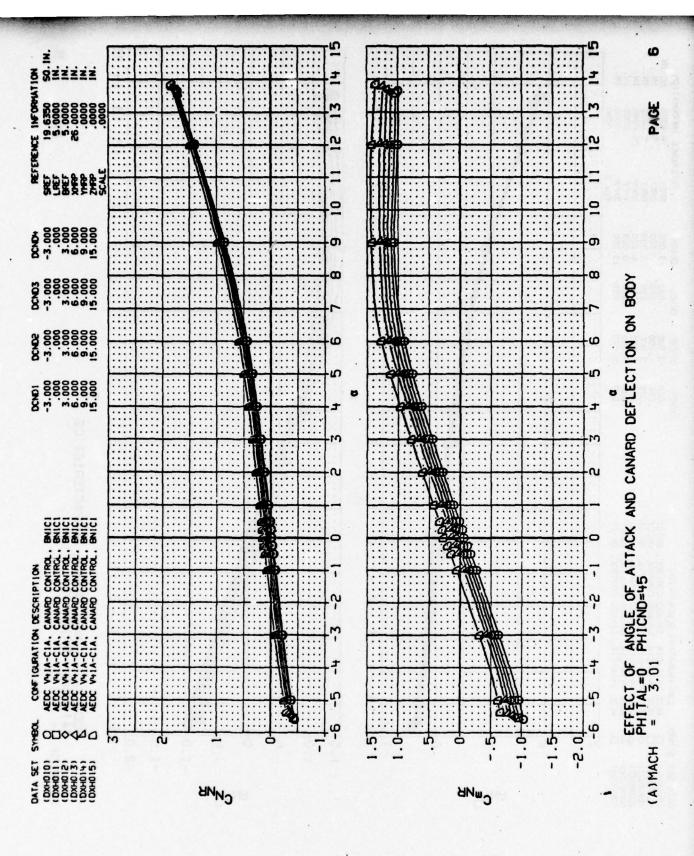
Tabulations of the plotted data and corresponding source data are available from Data Management Services Operations.



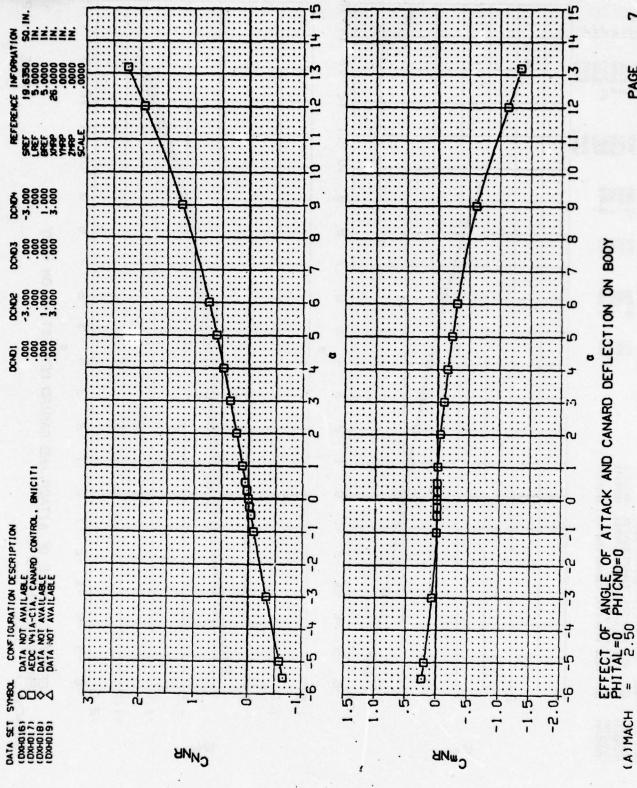


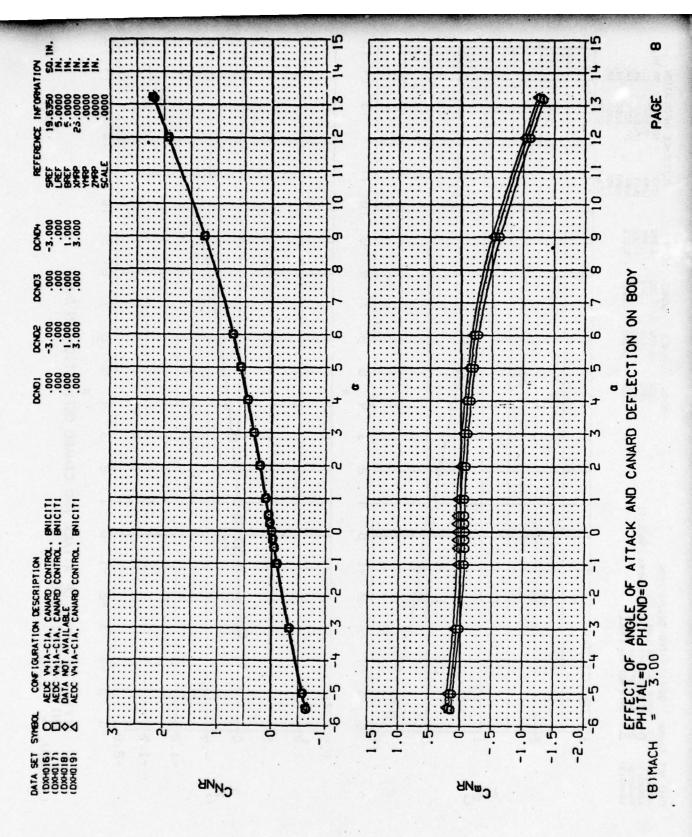


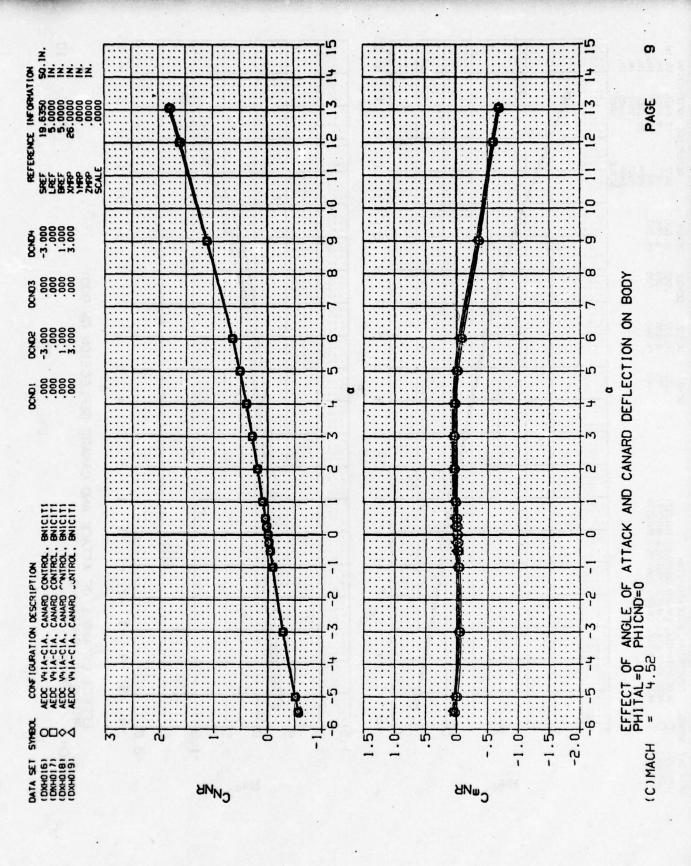


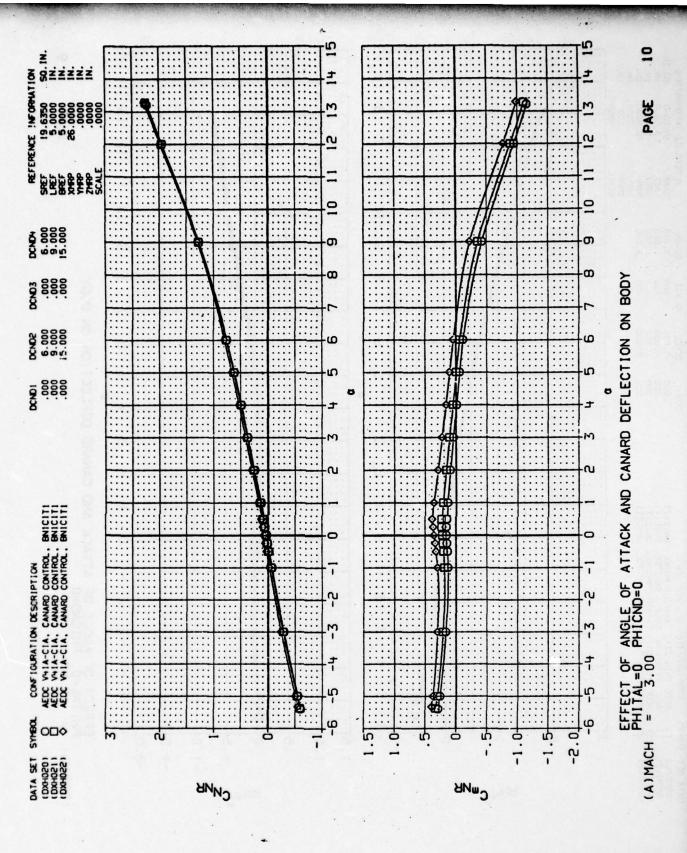


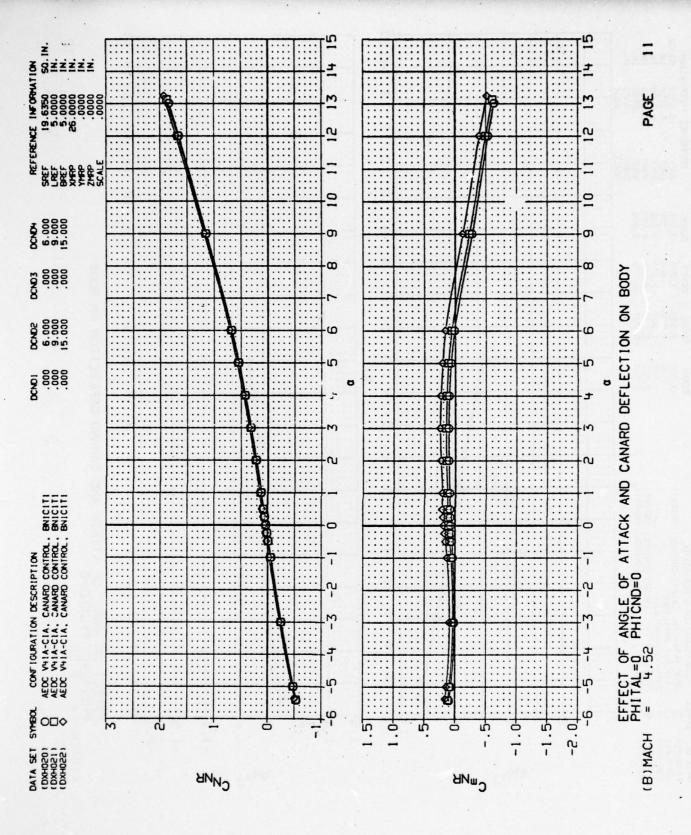


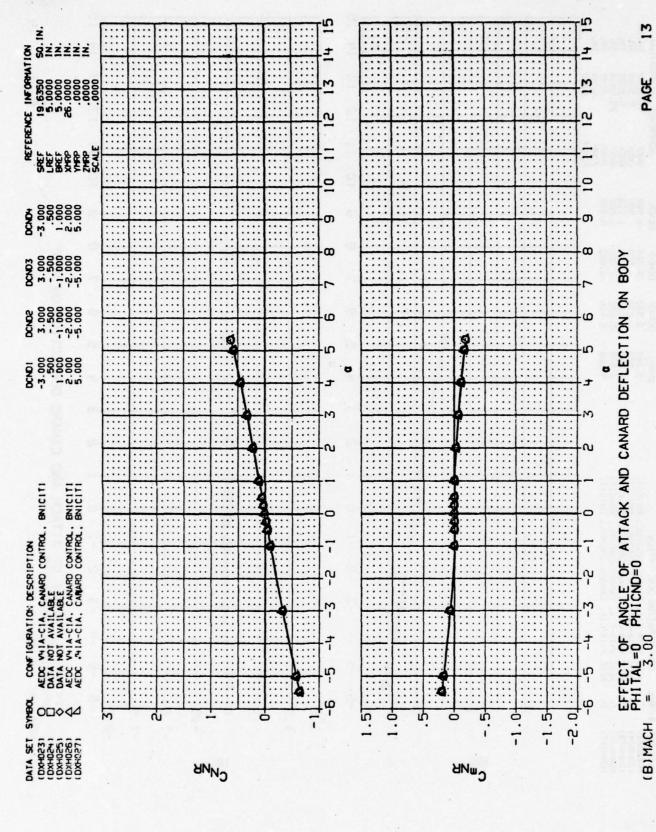


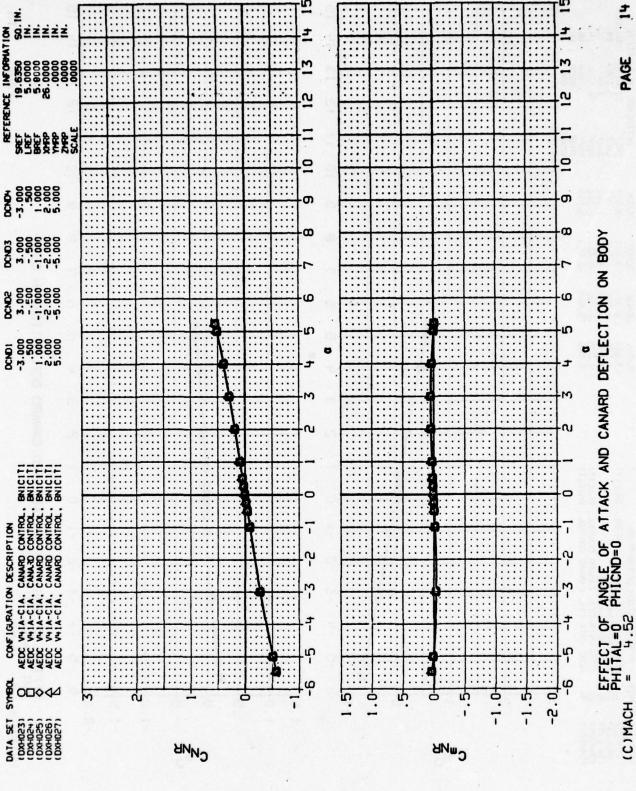


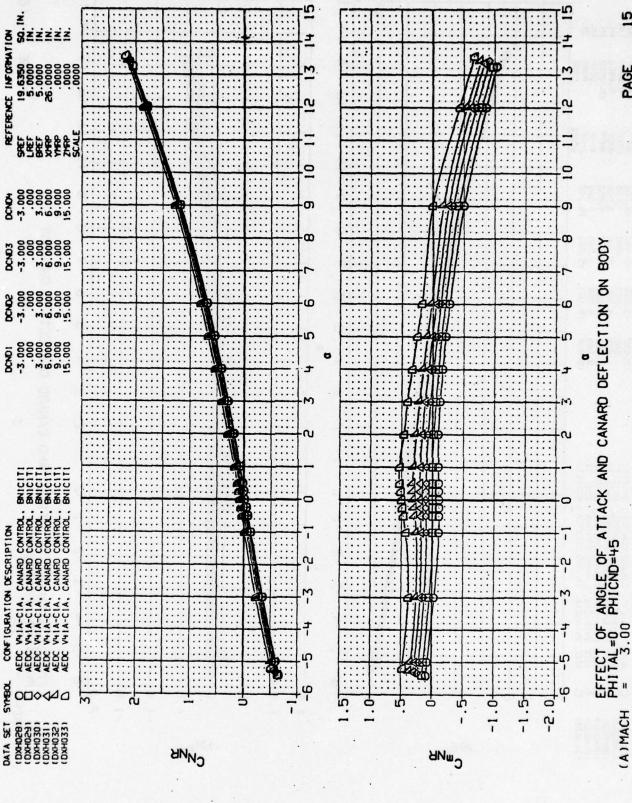


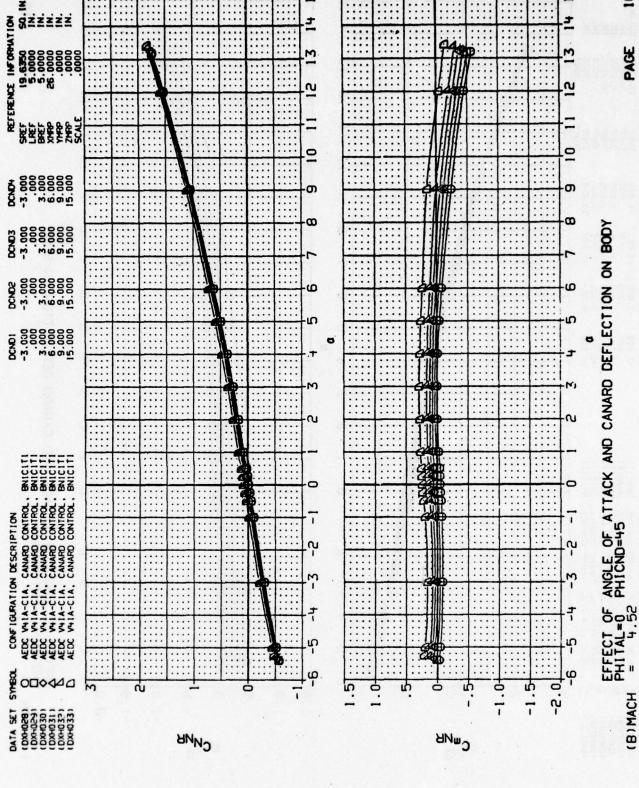


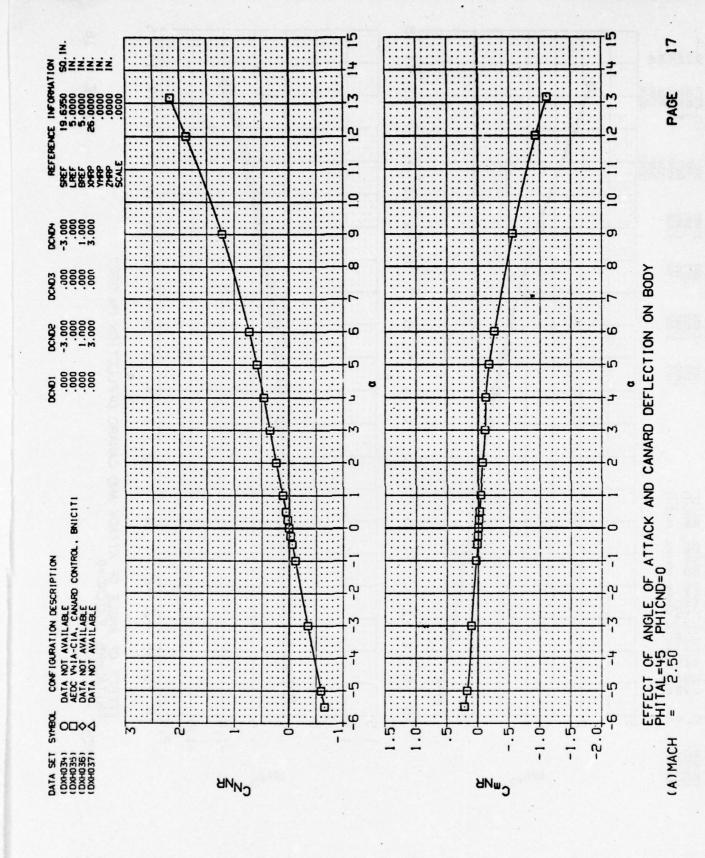


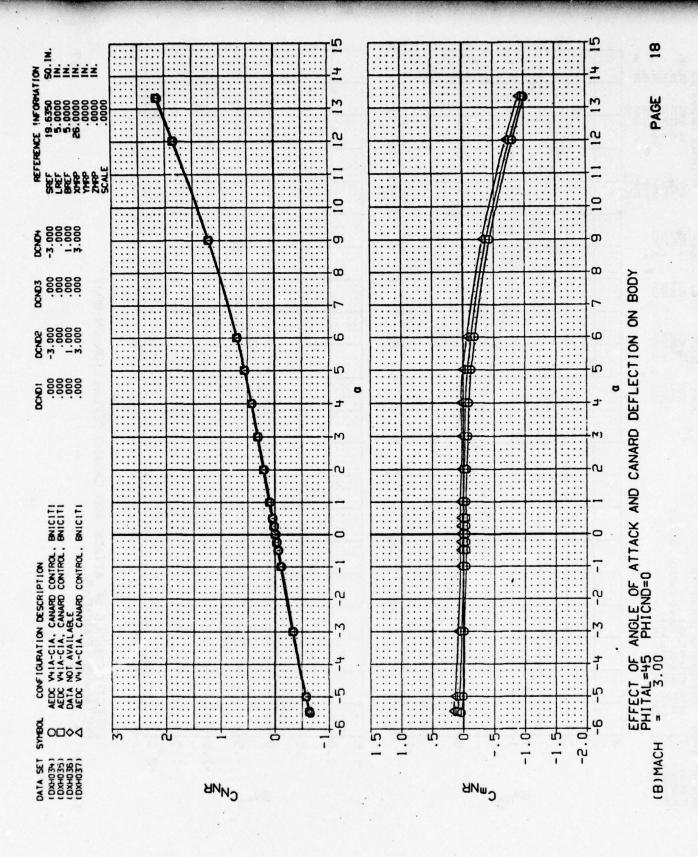


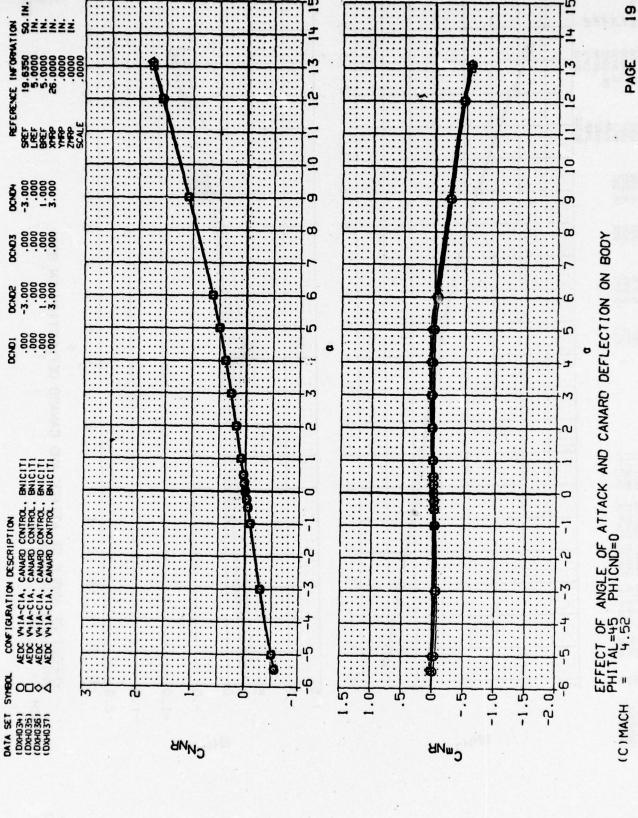


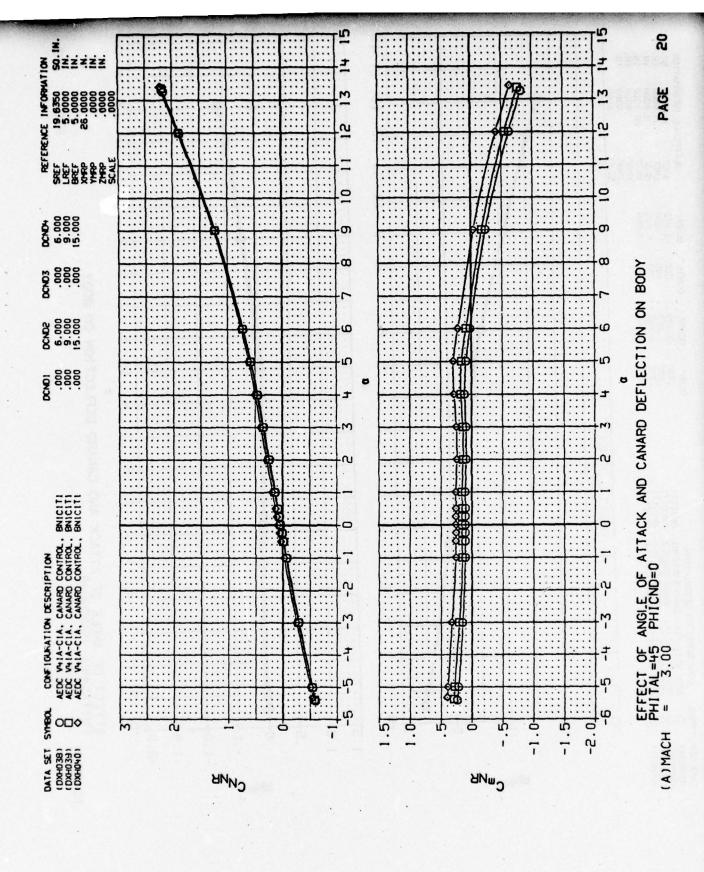




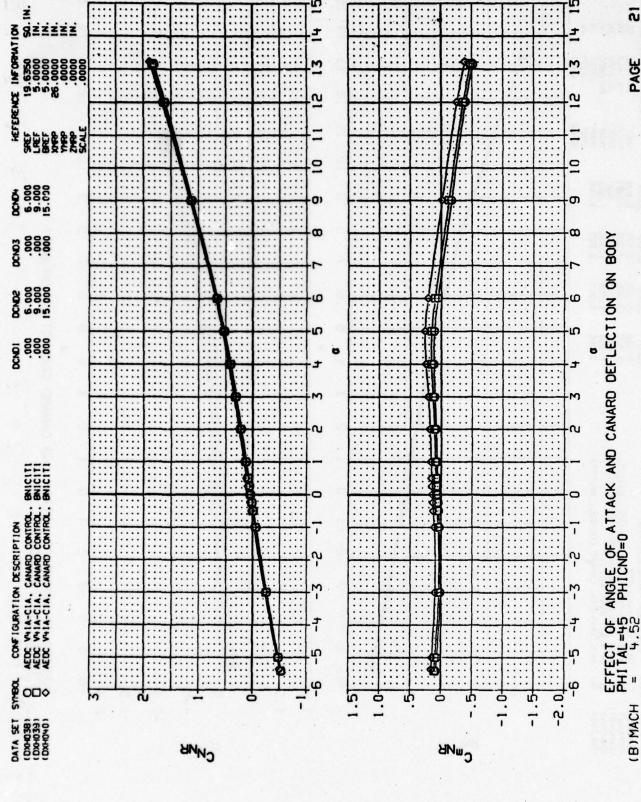


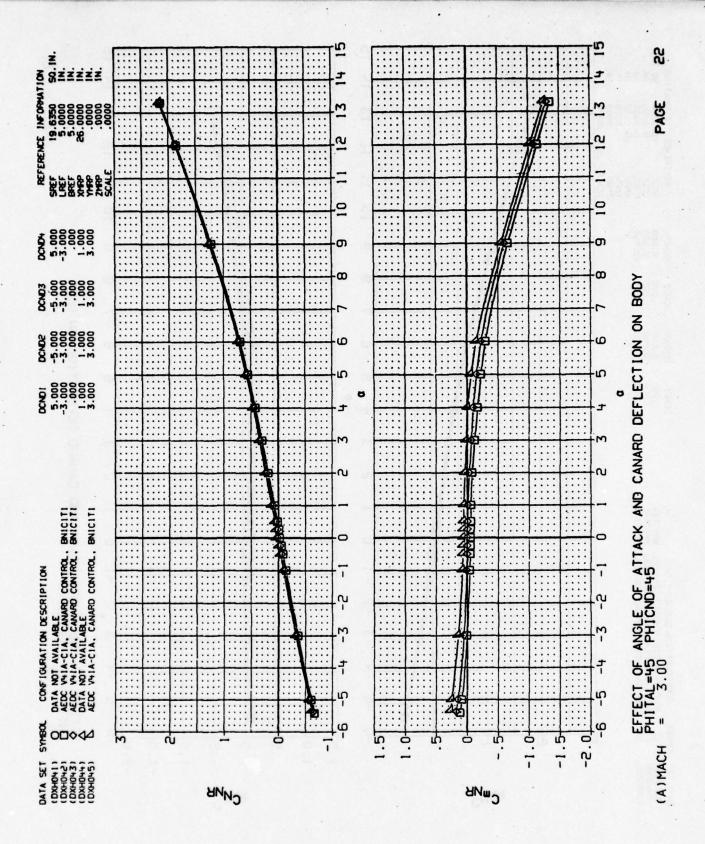


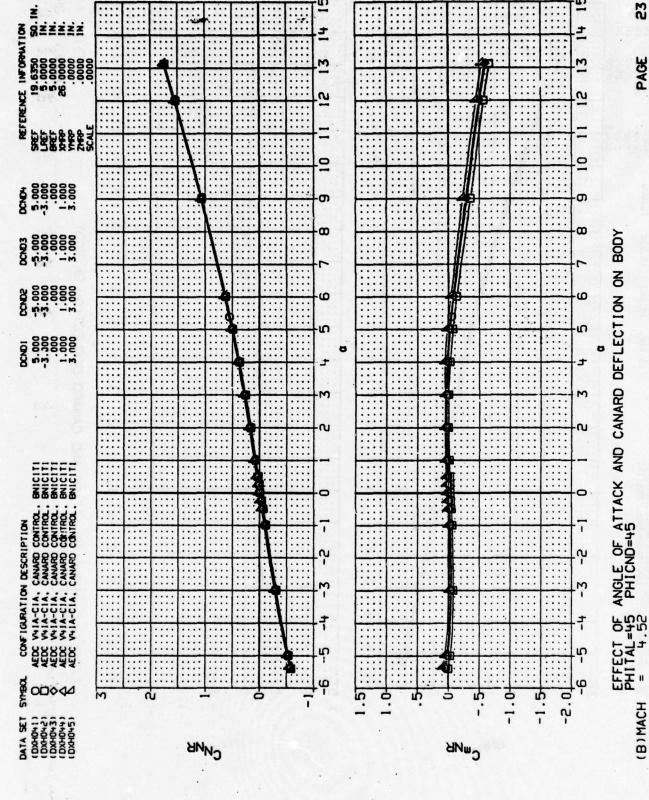


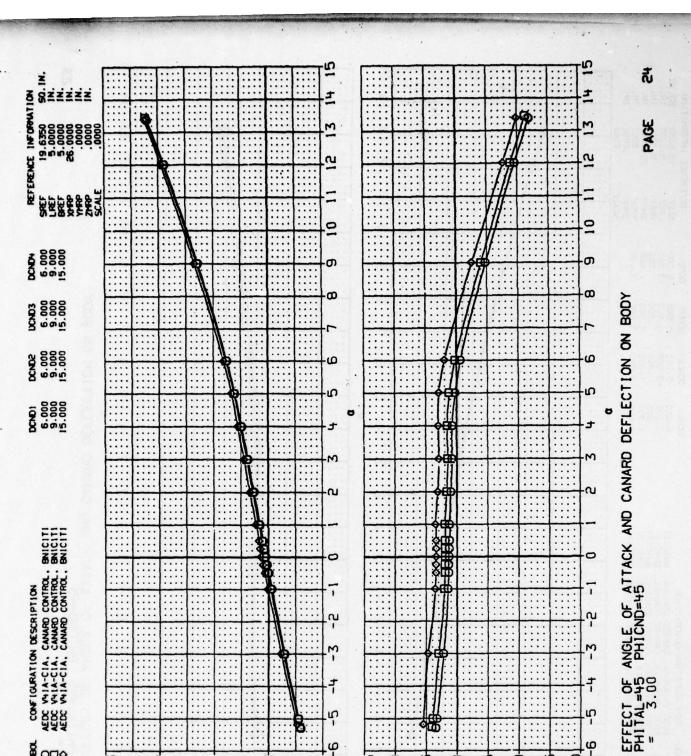


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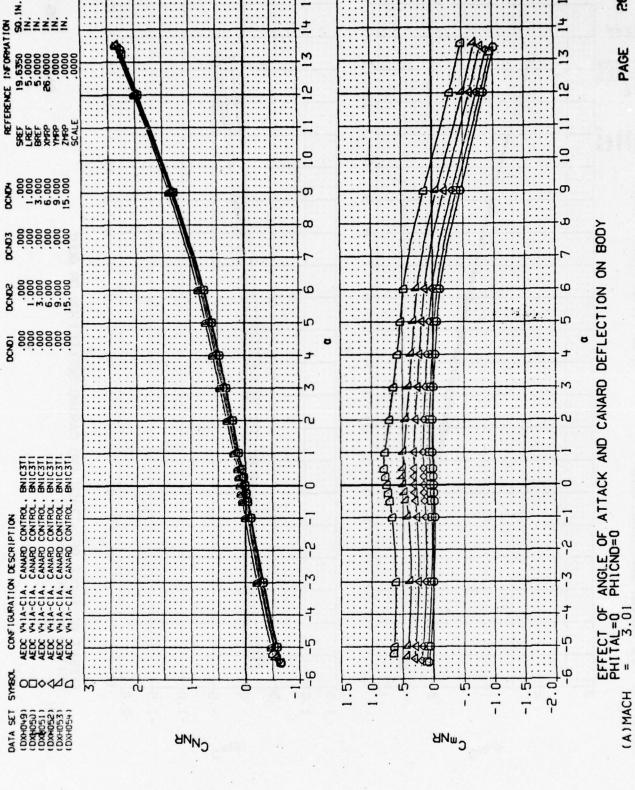
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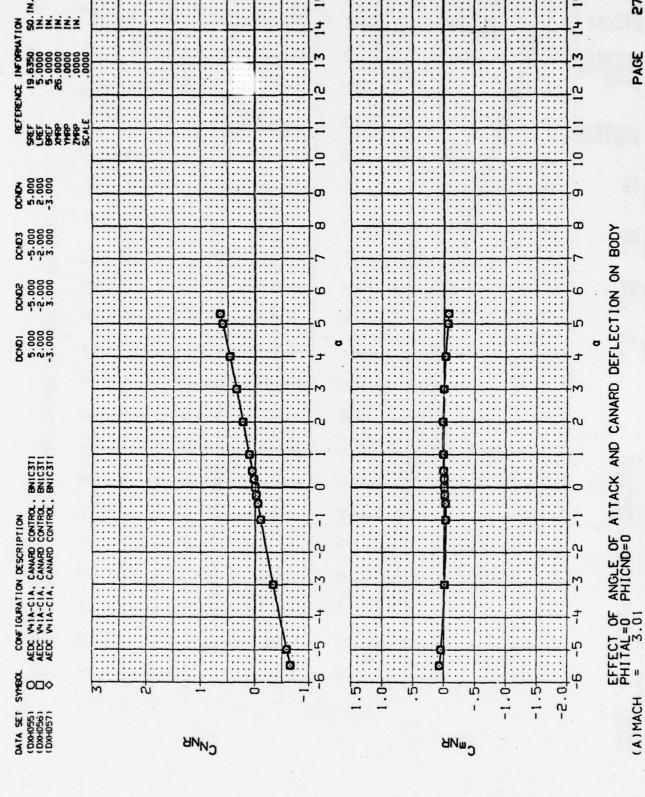
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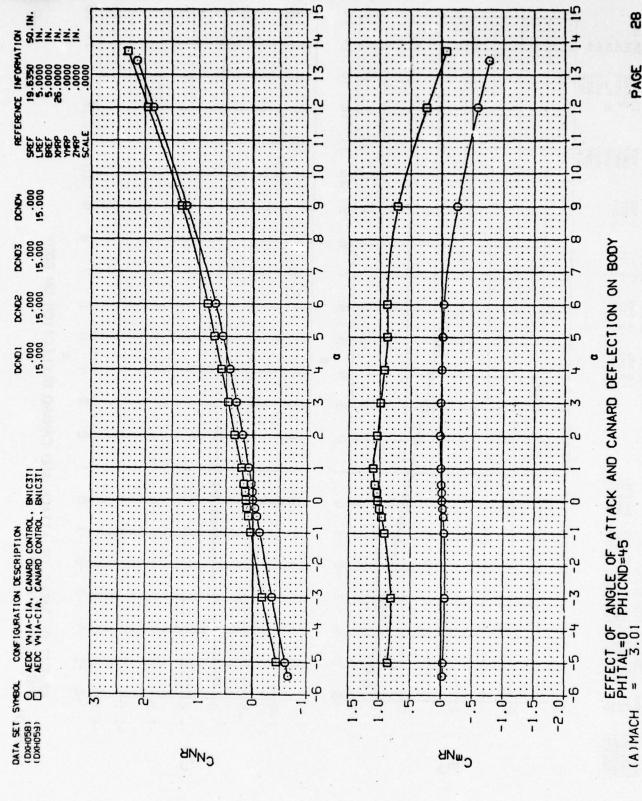
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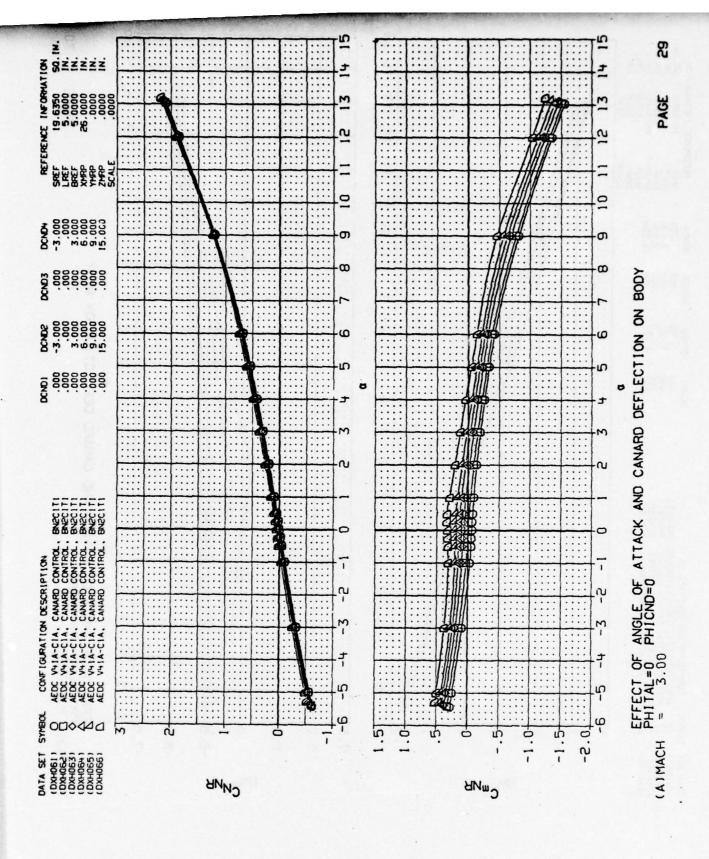
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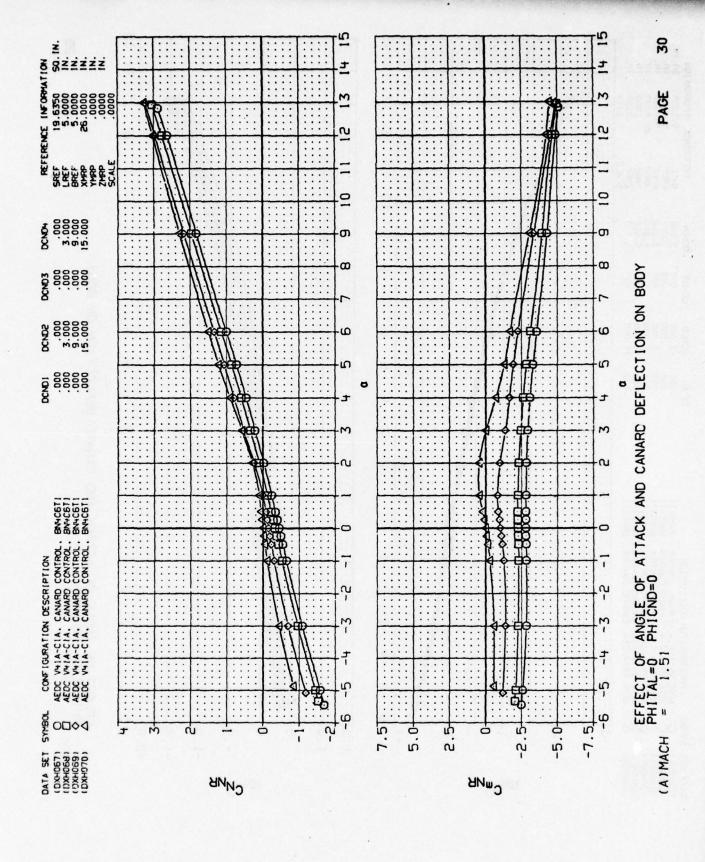


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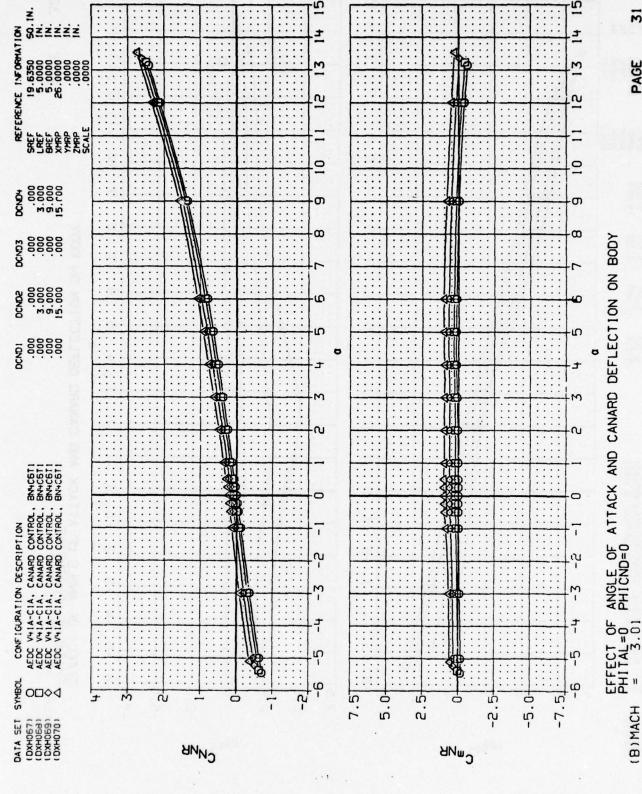


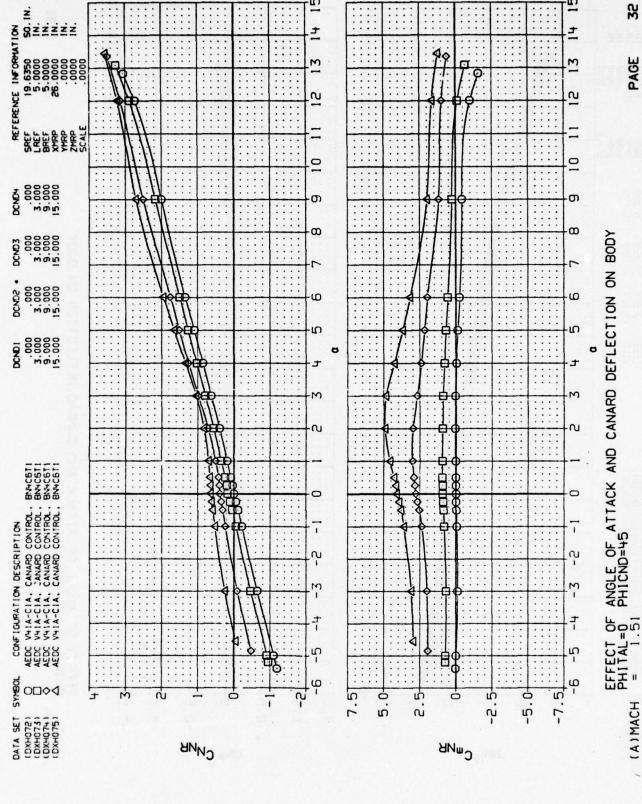


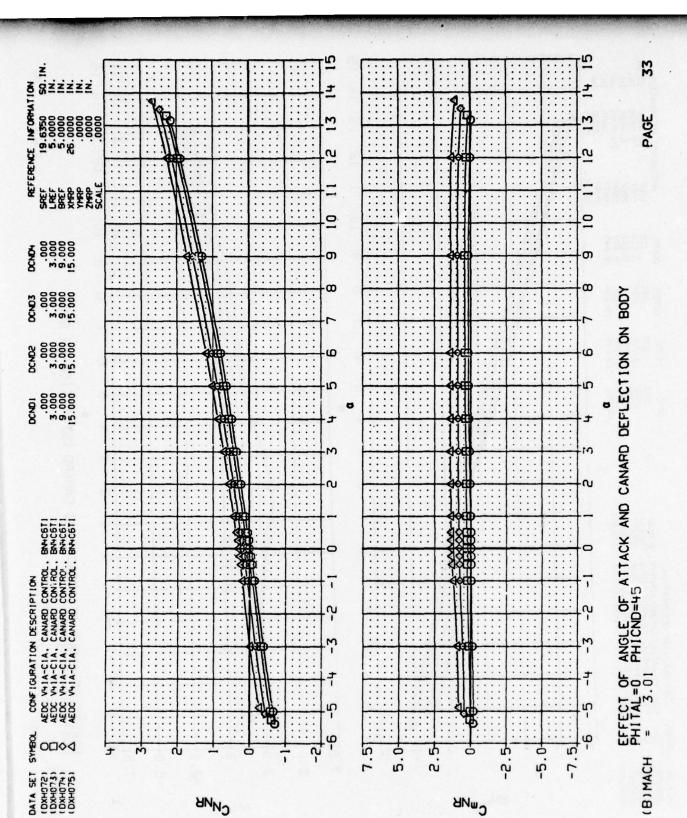


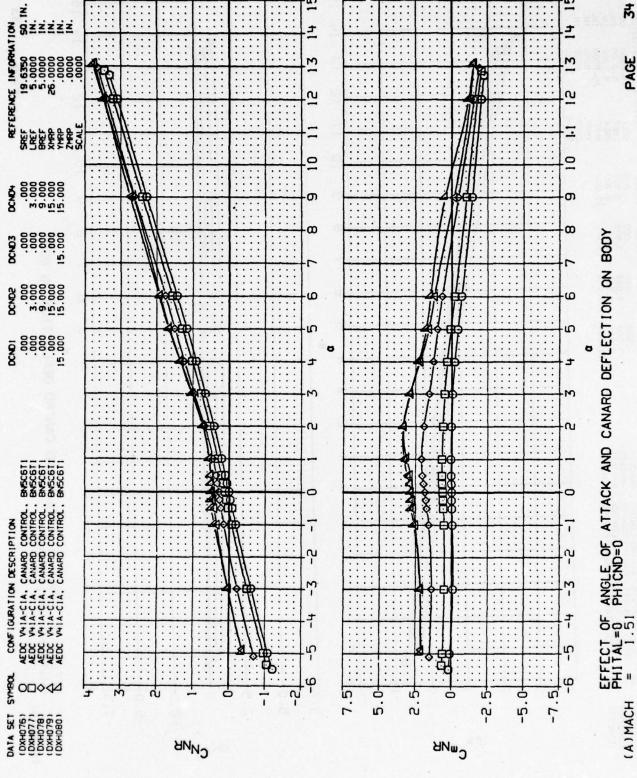


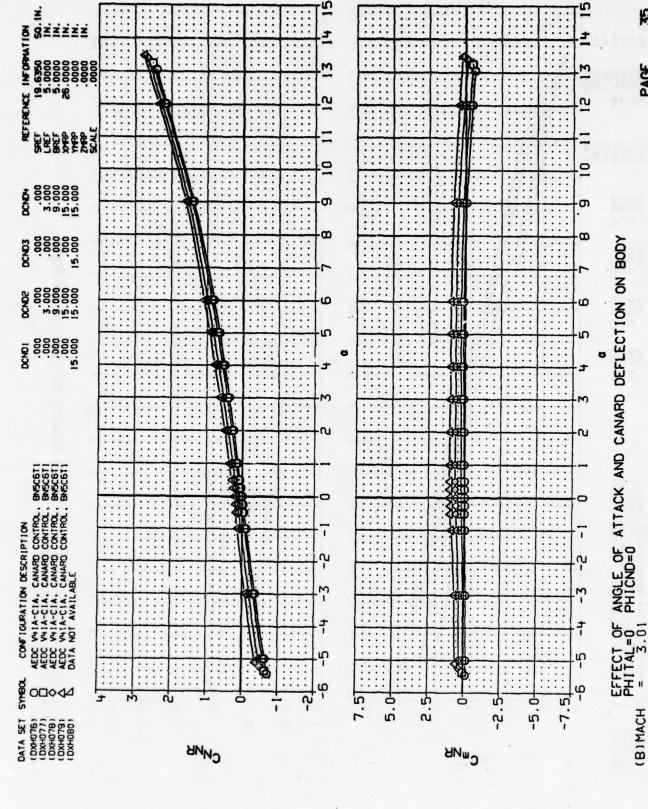
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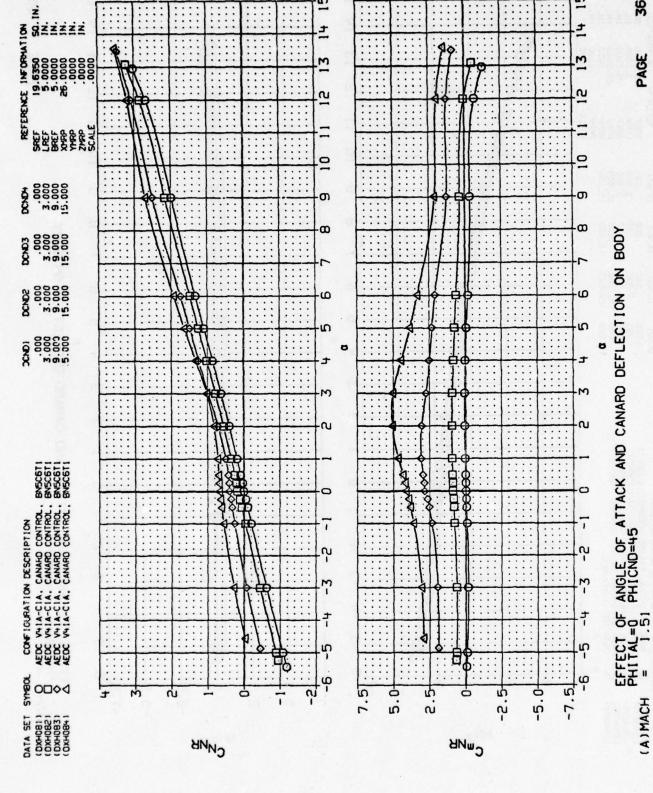


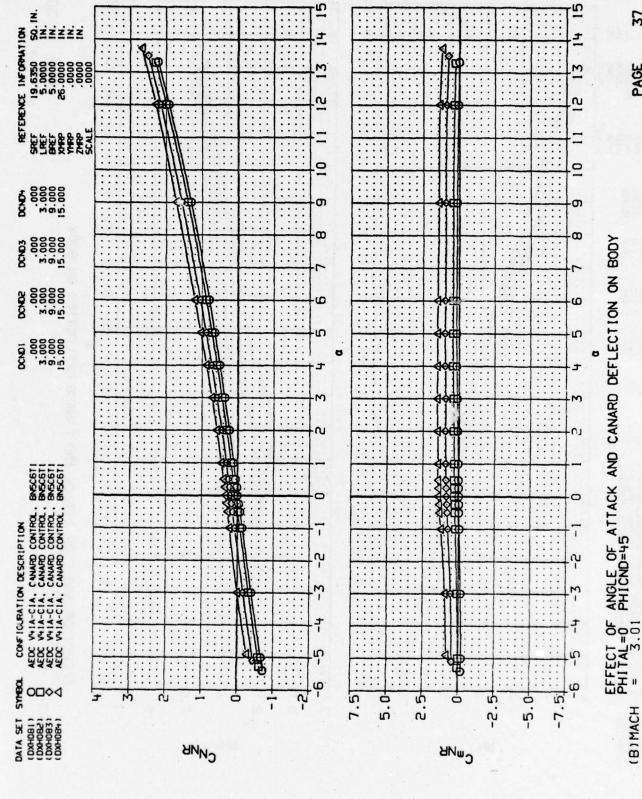


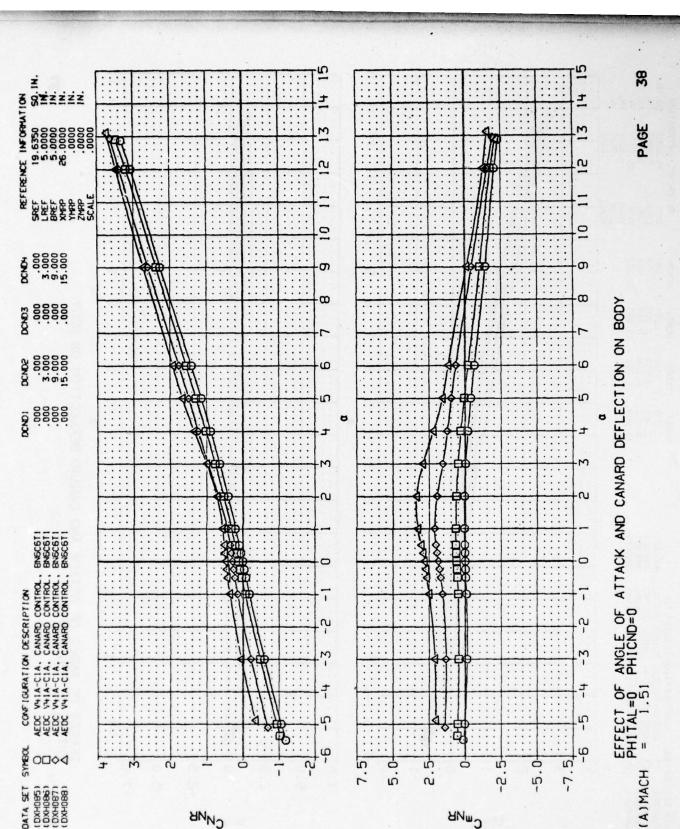




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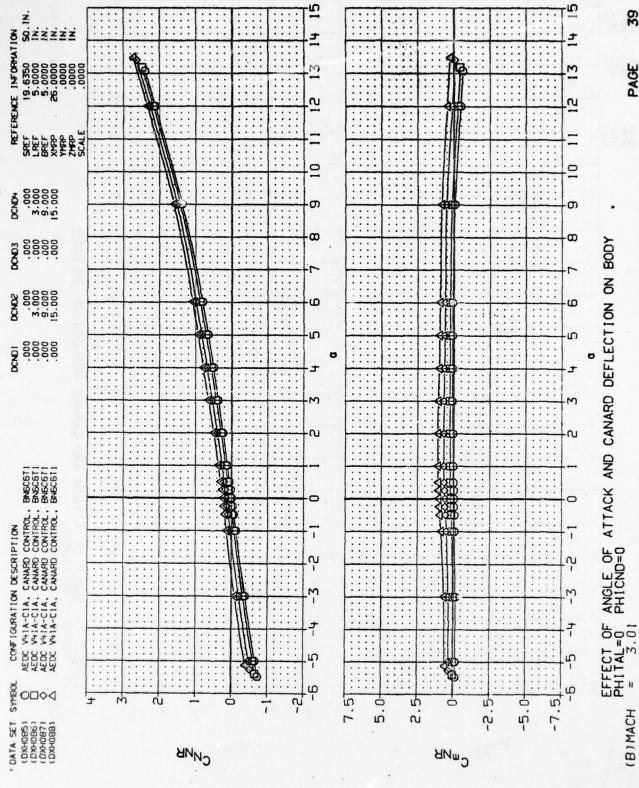
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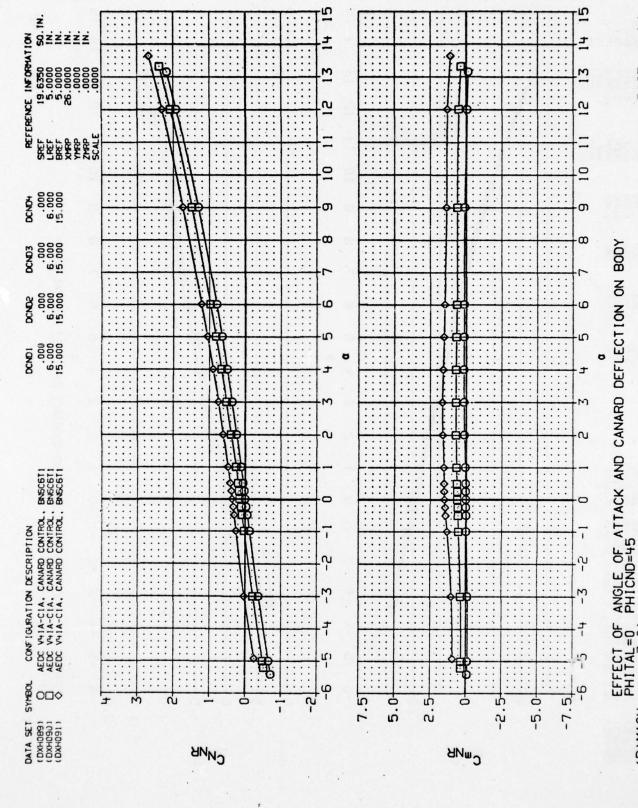
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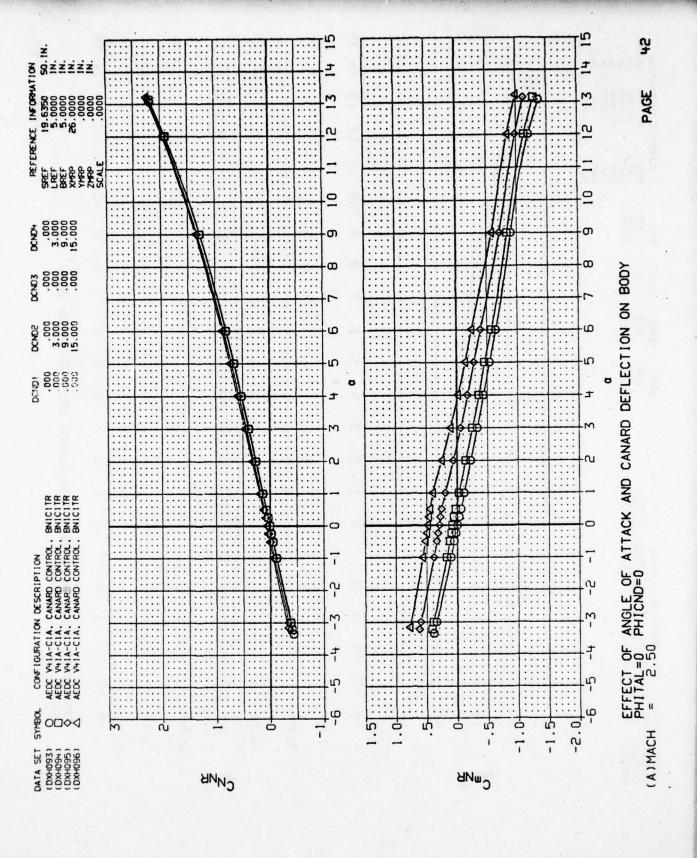




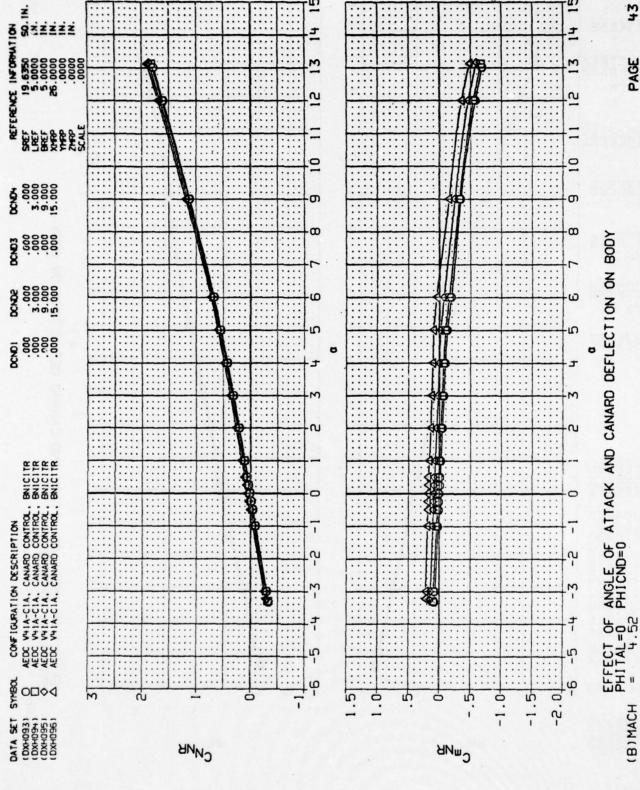


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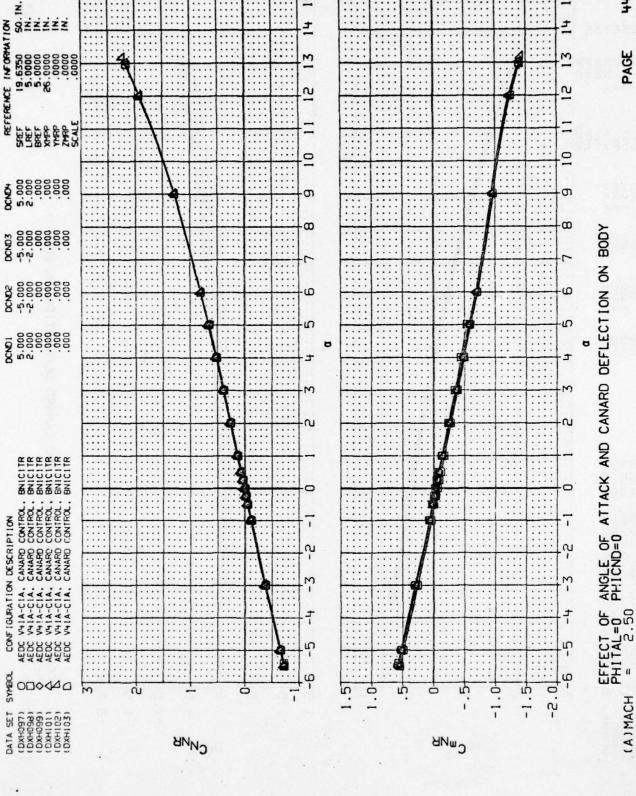
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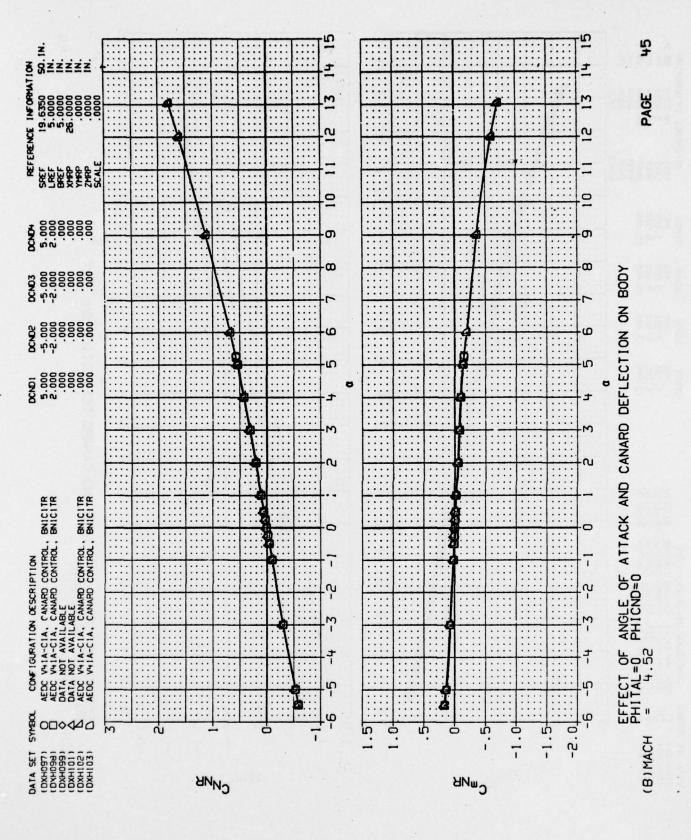


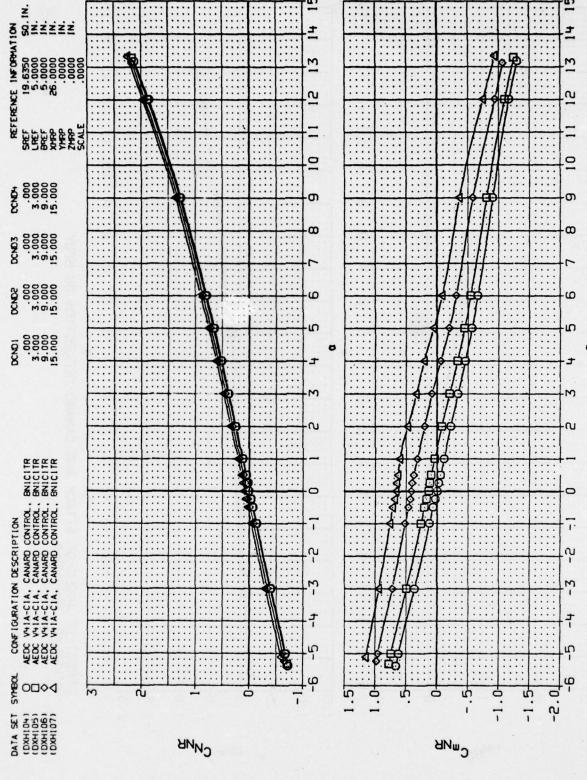
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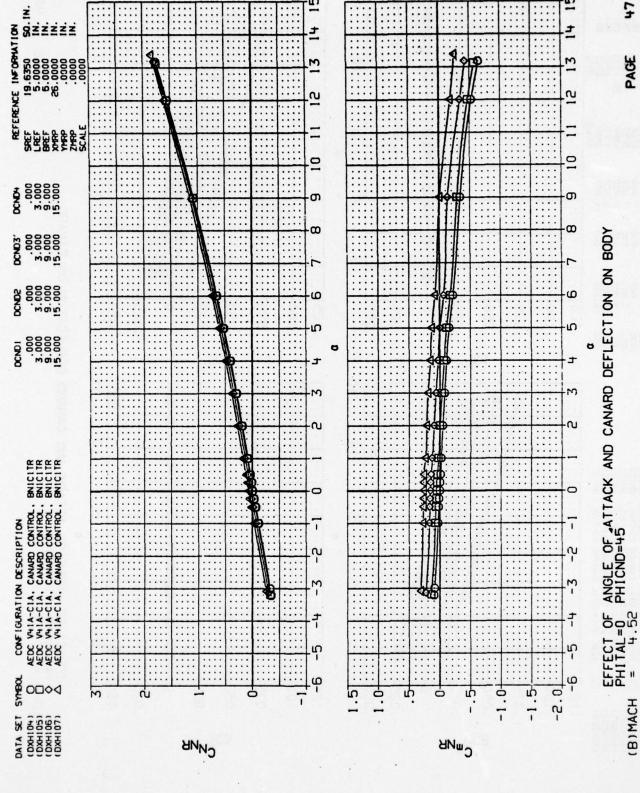
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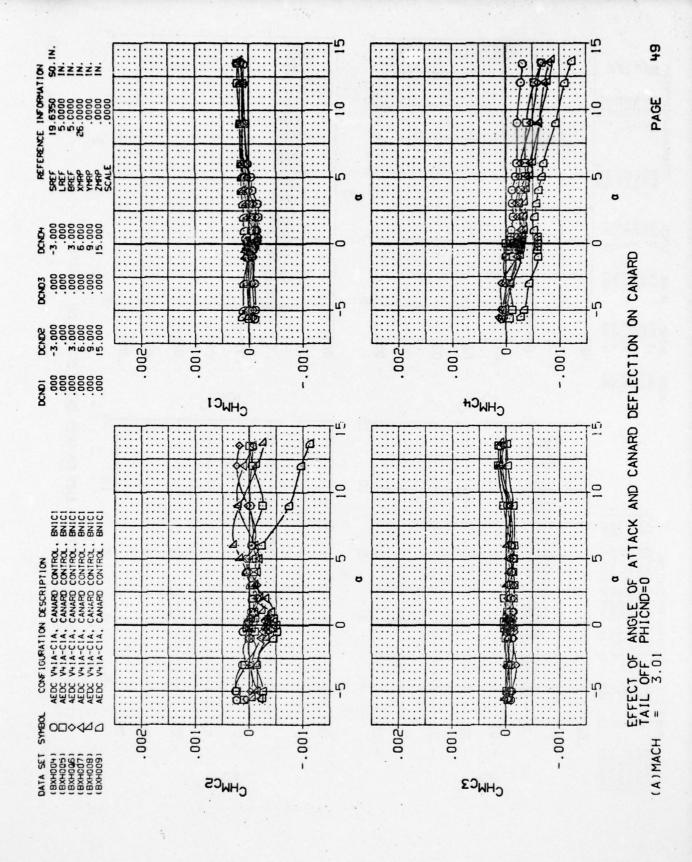


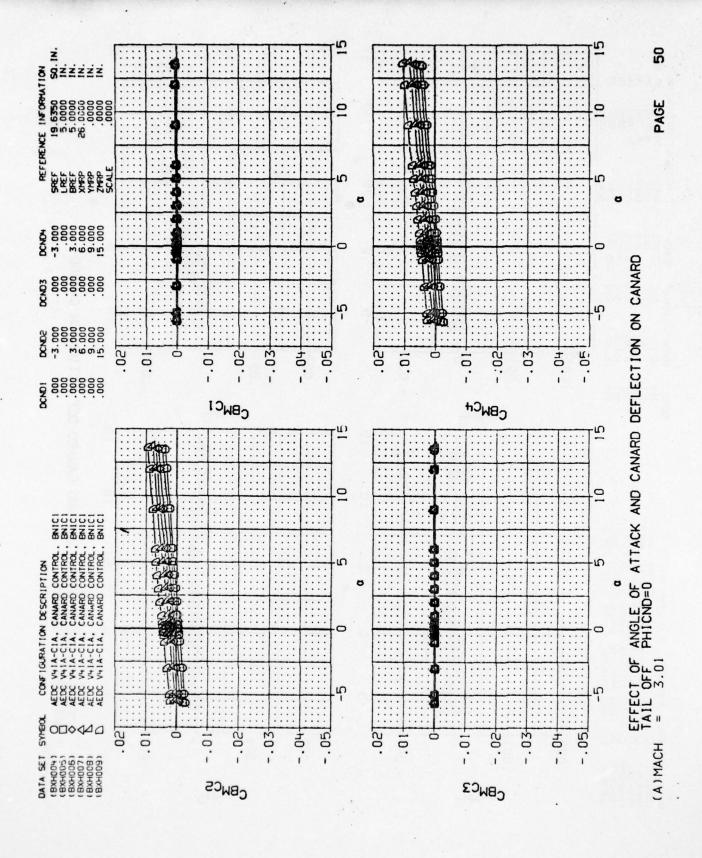




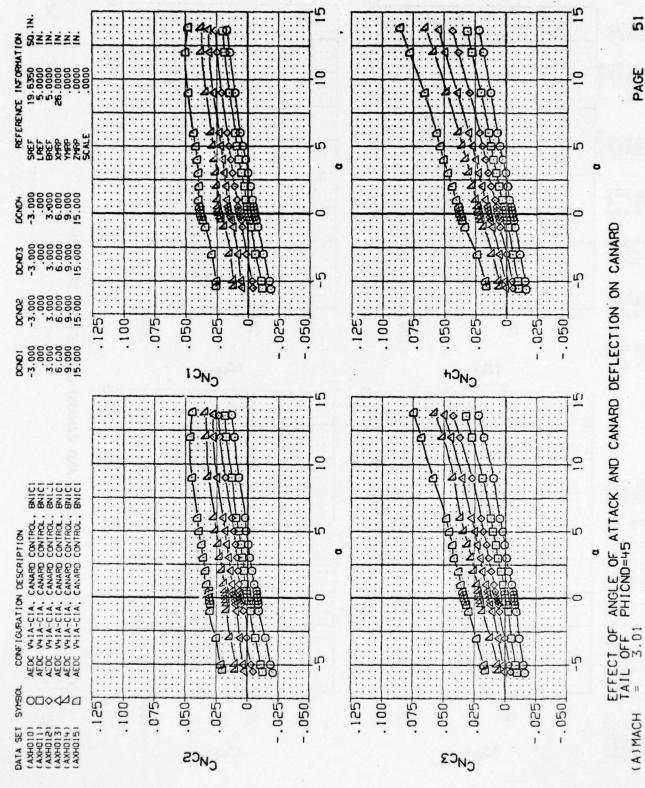
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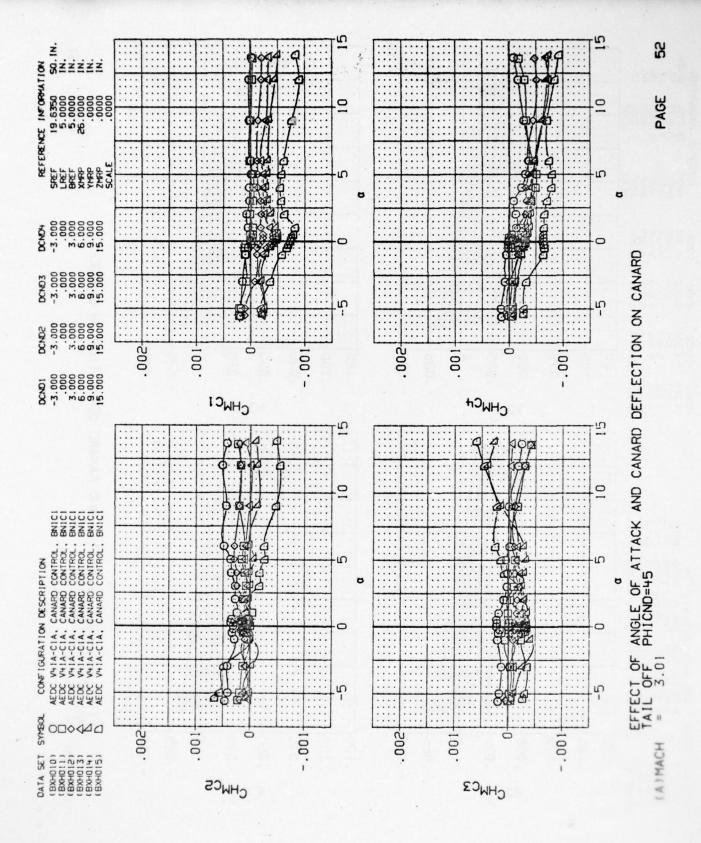




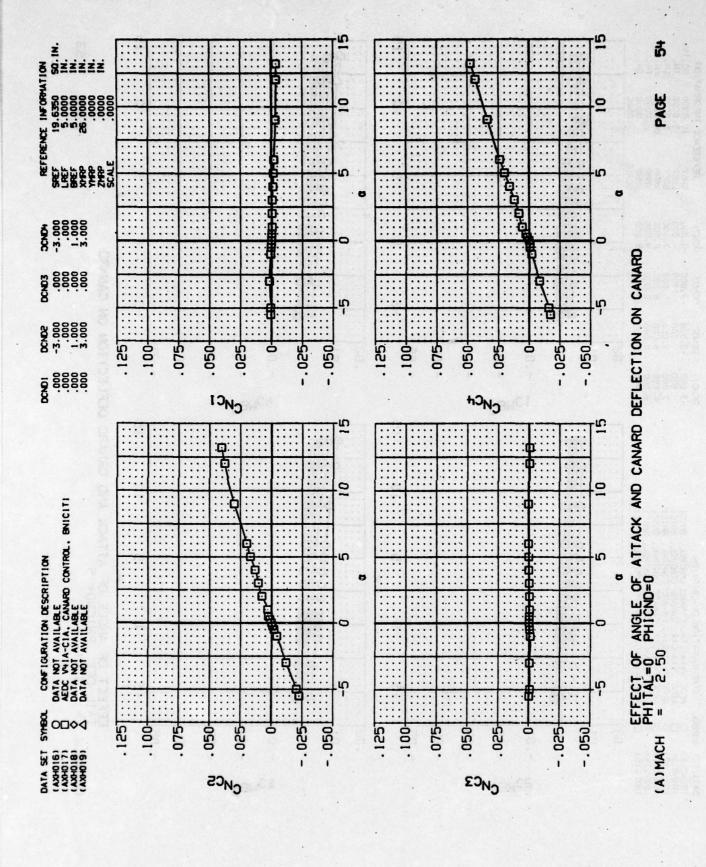


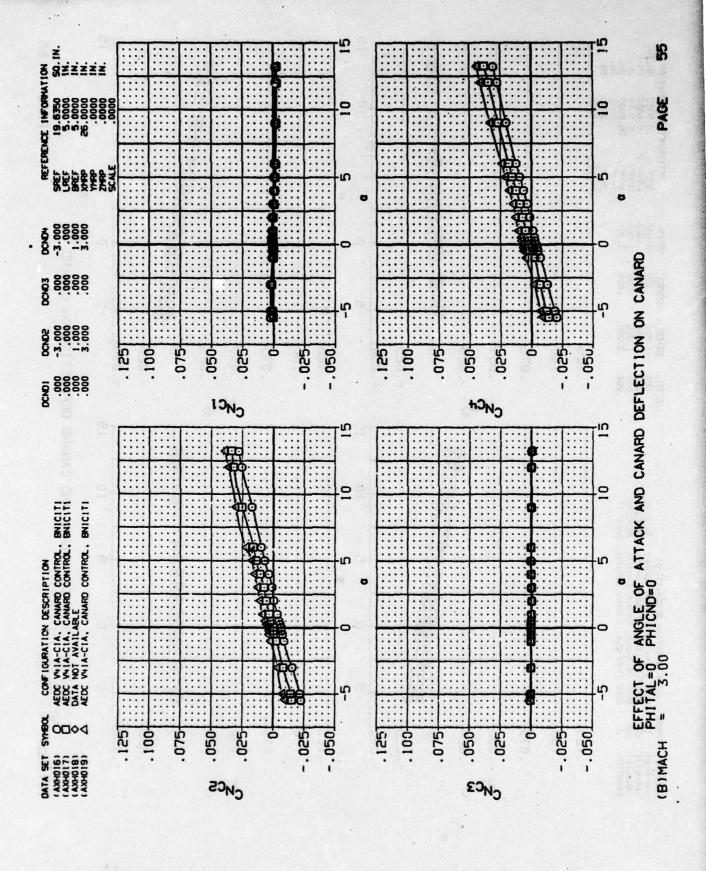
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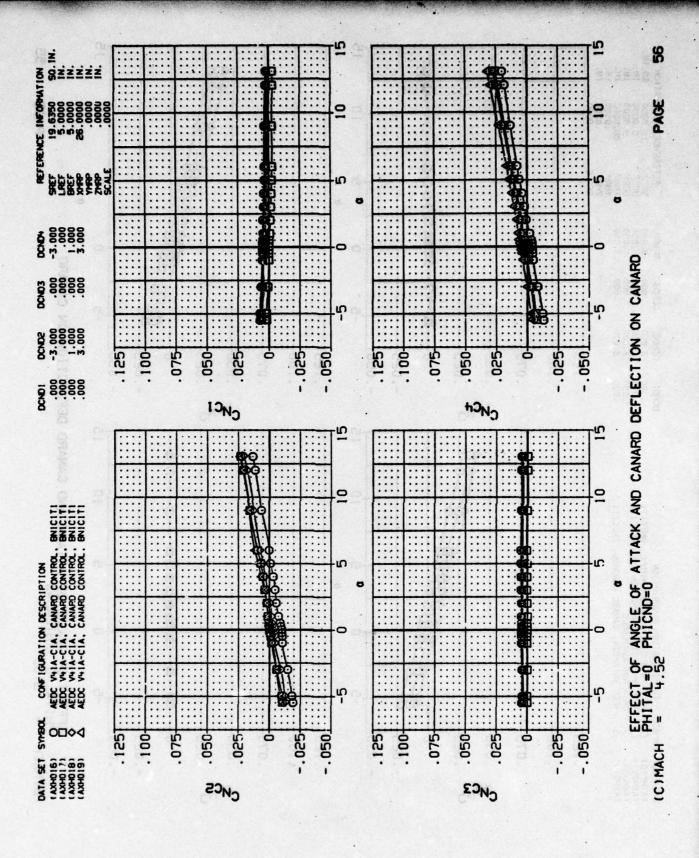


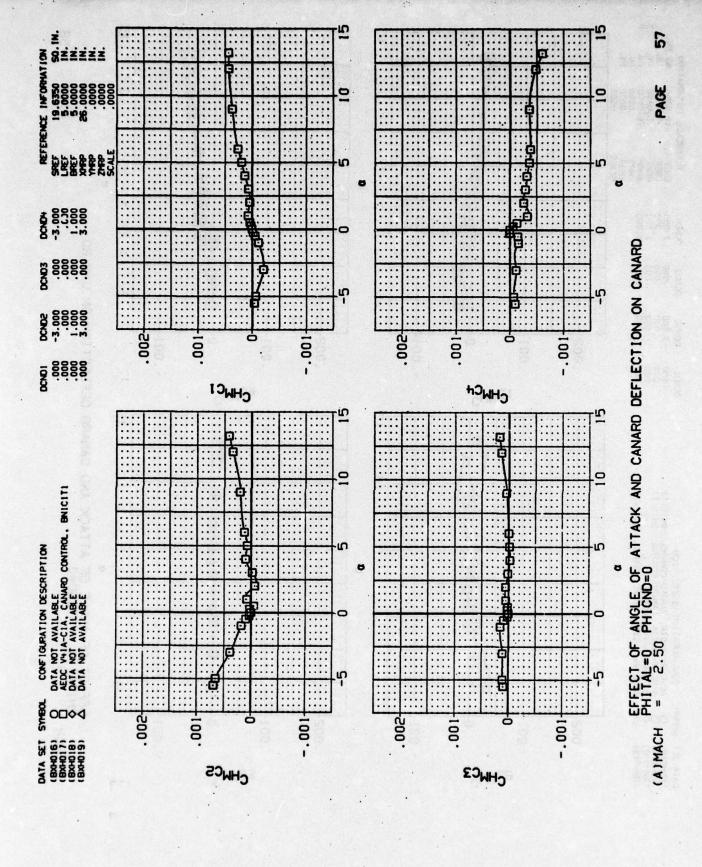


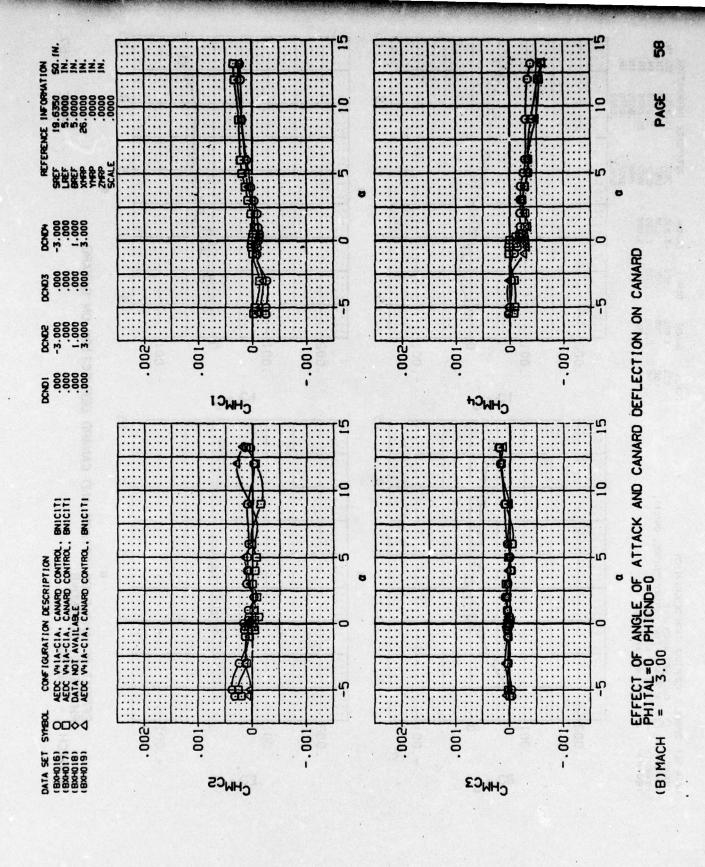
ARMY MISSILE RESEARCH DEVELOPMENT AND ENGINEERING LAB--ETC F/G 20/4
AN EXPERIMENTAL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTIC--ETC(U)
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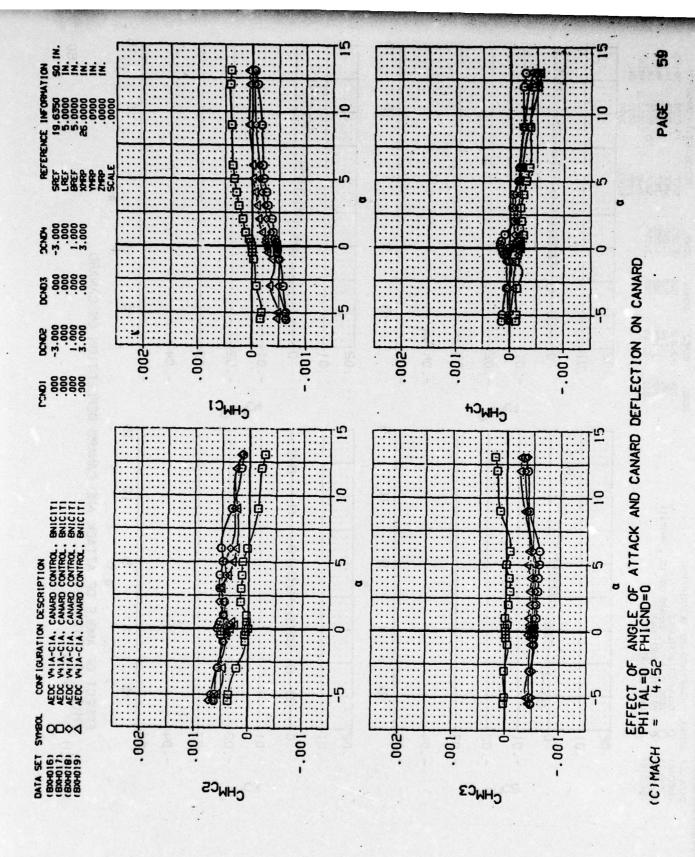


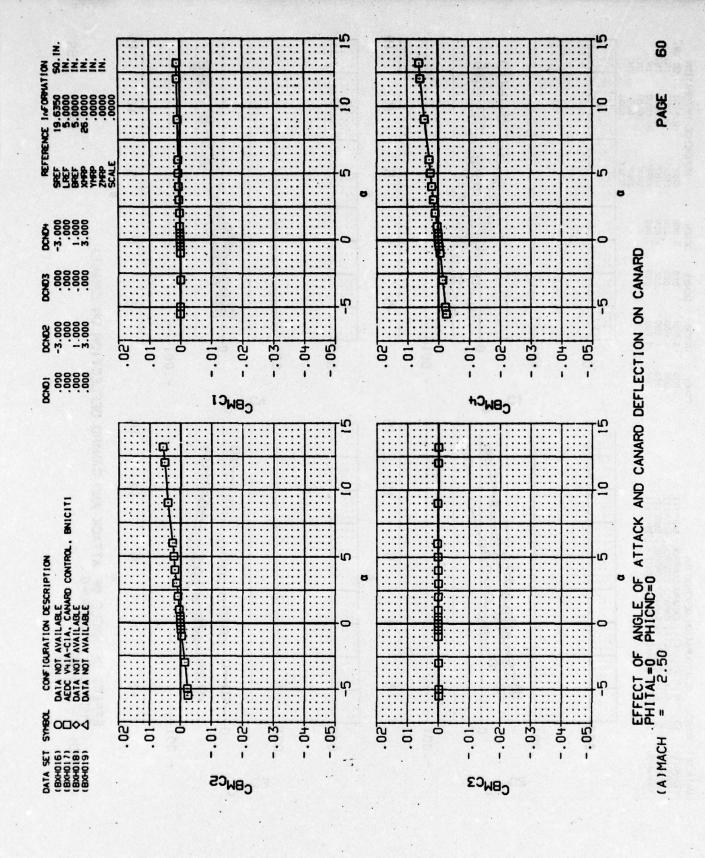


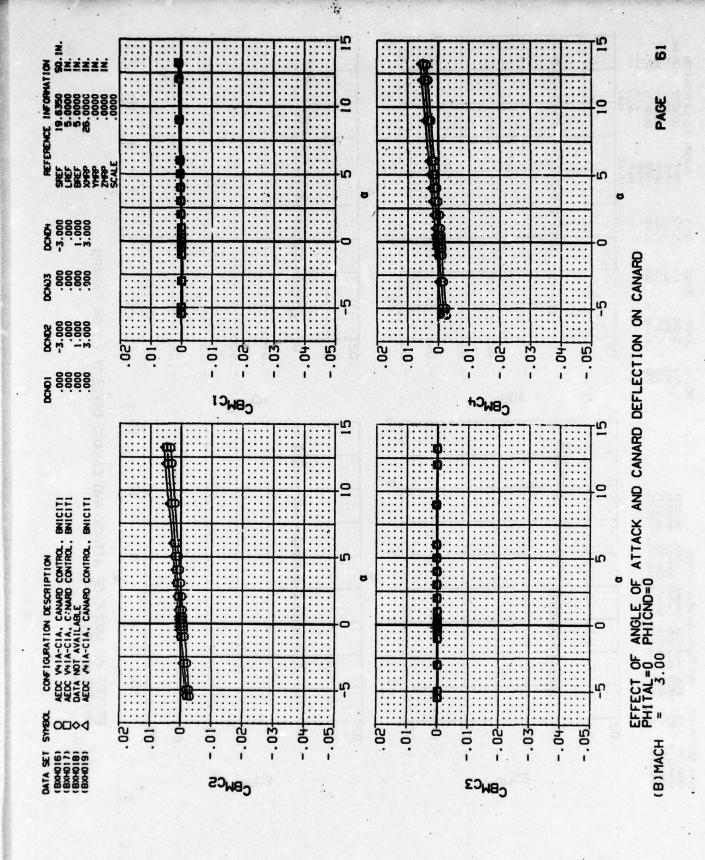


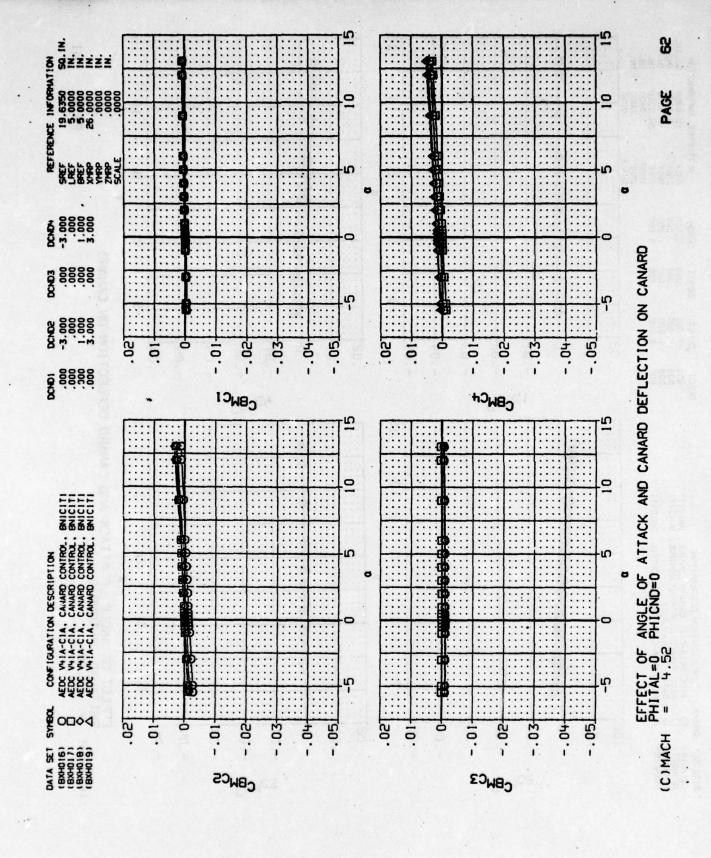


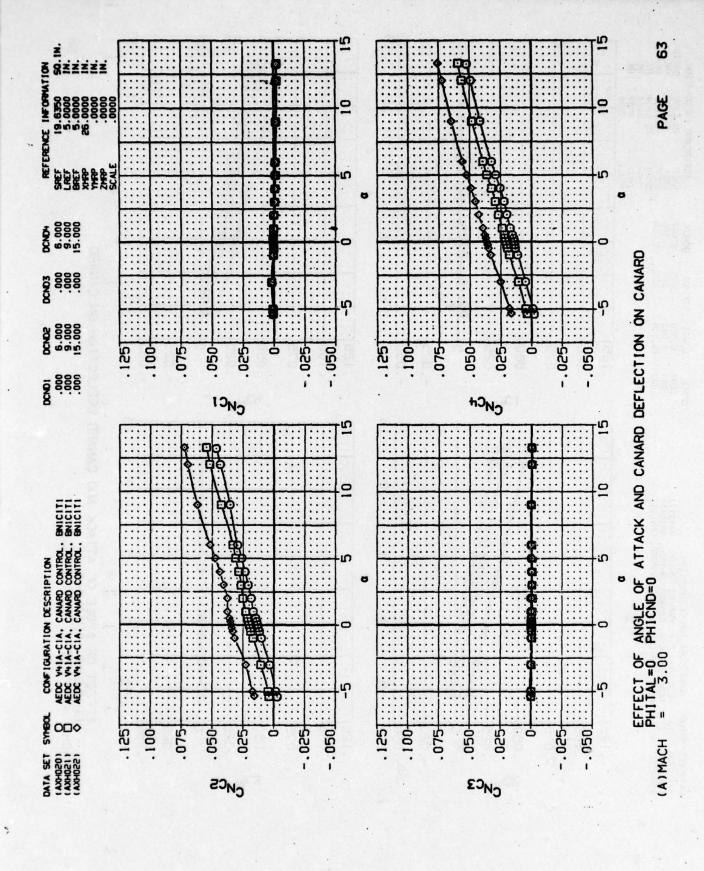


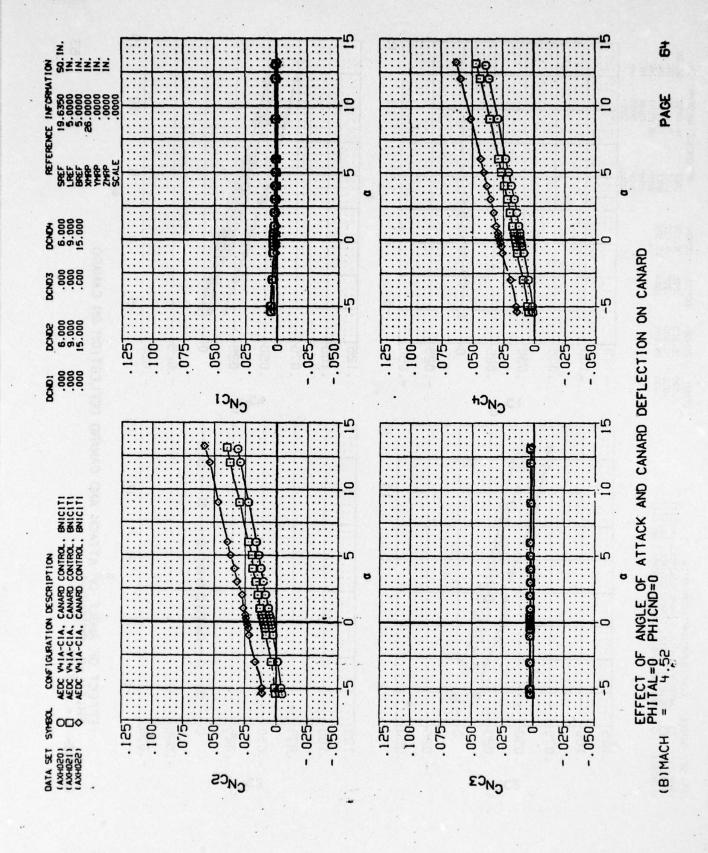


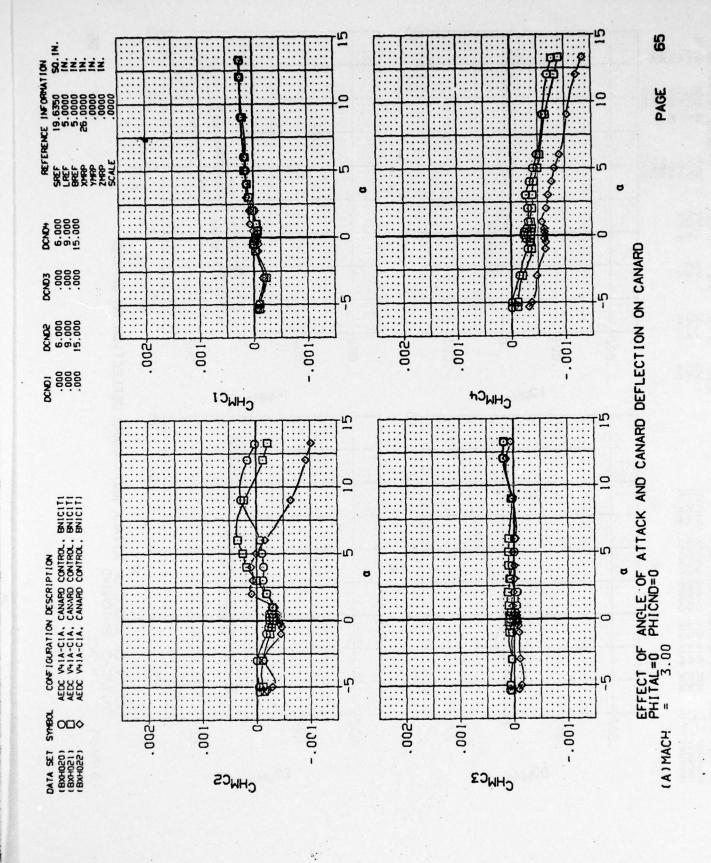


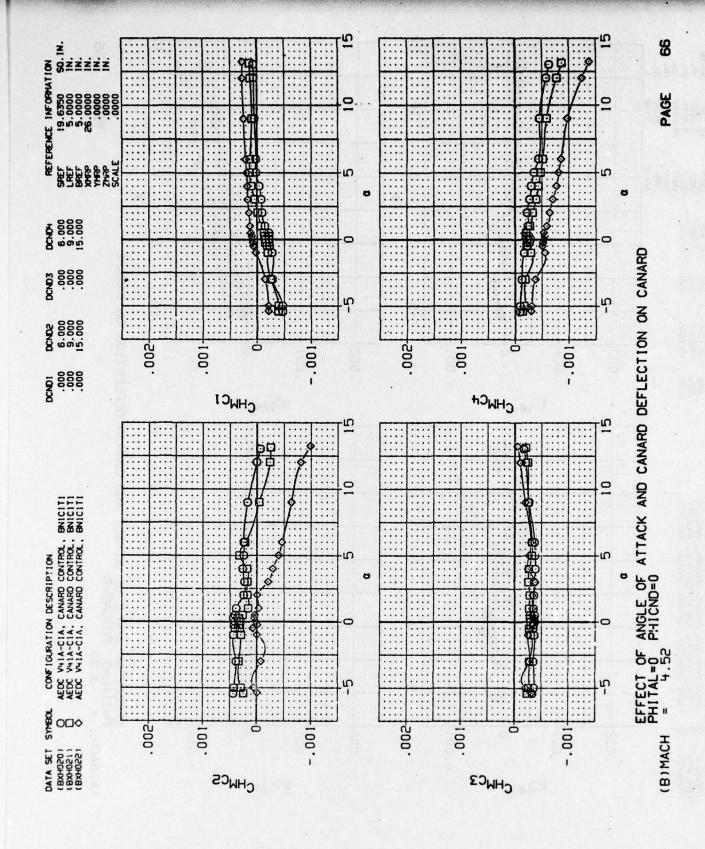


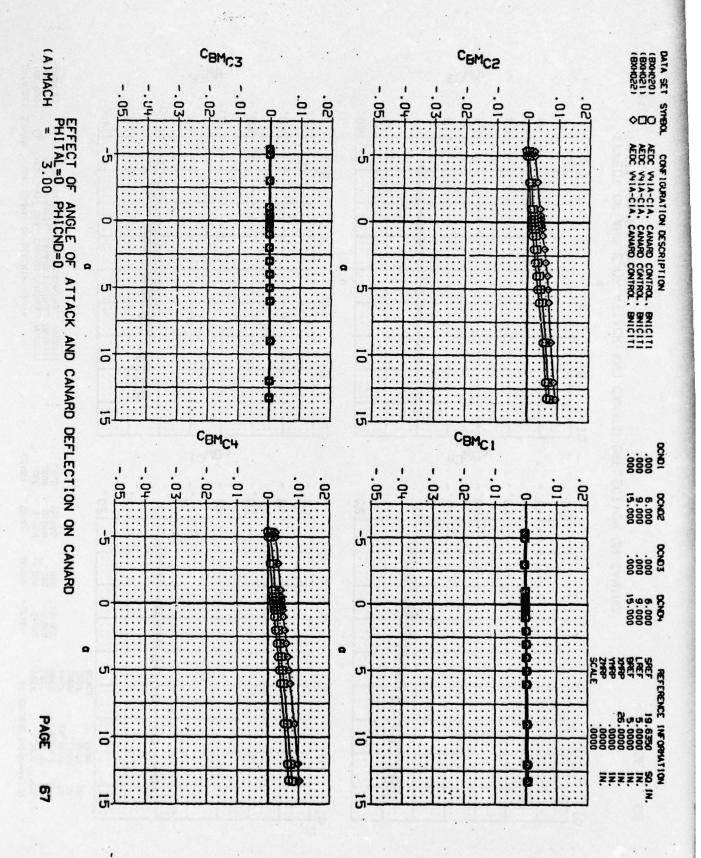


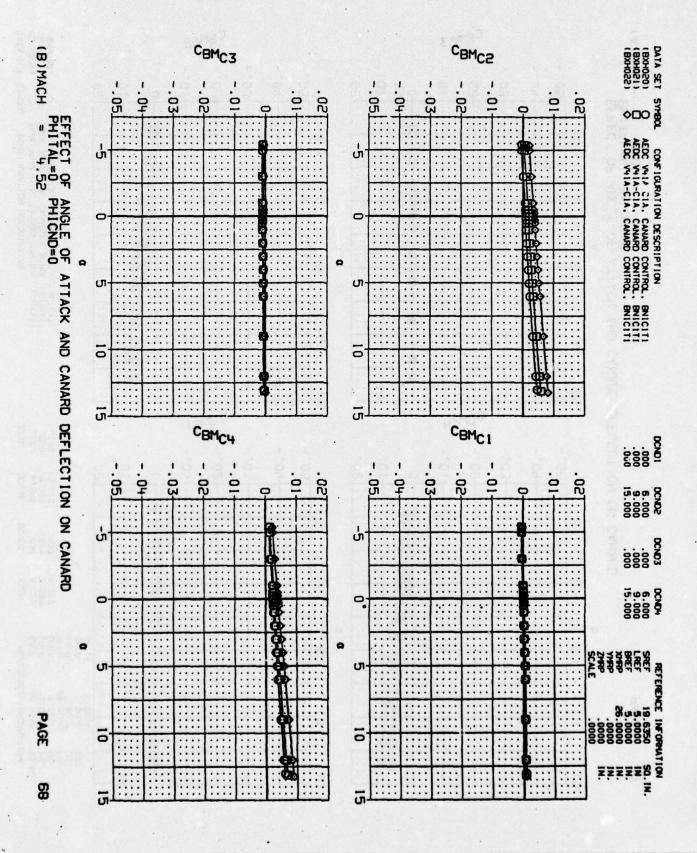


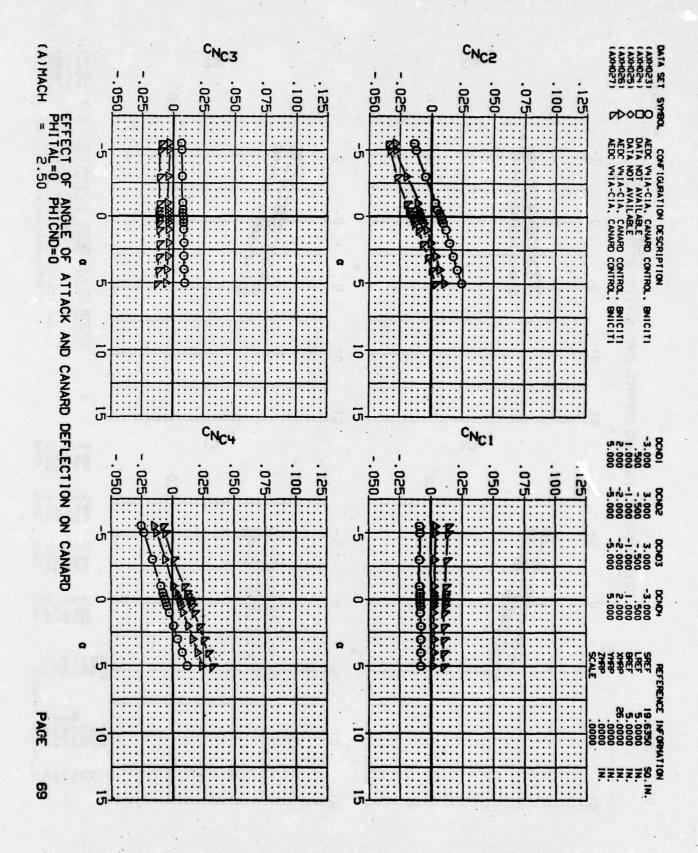


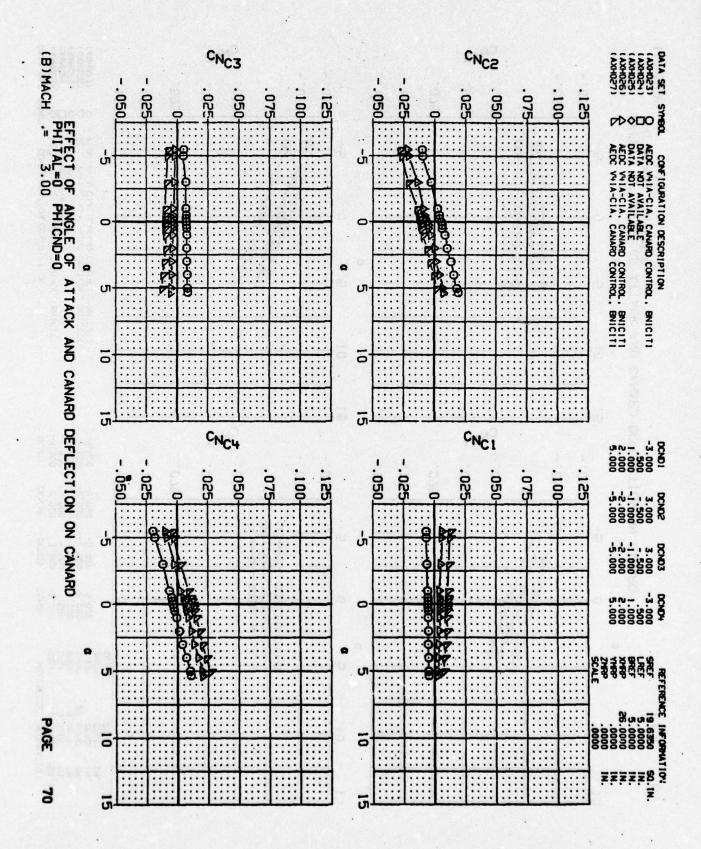


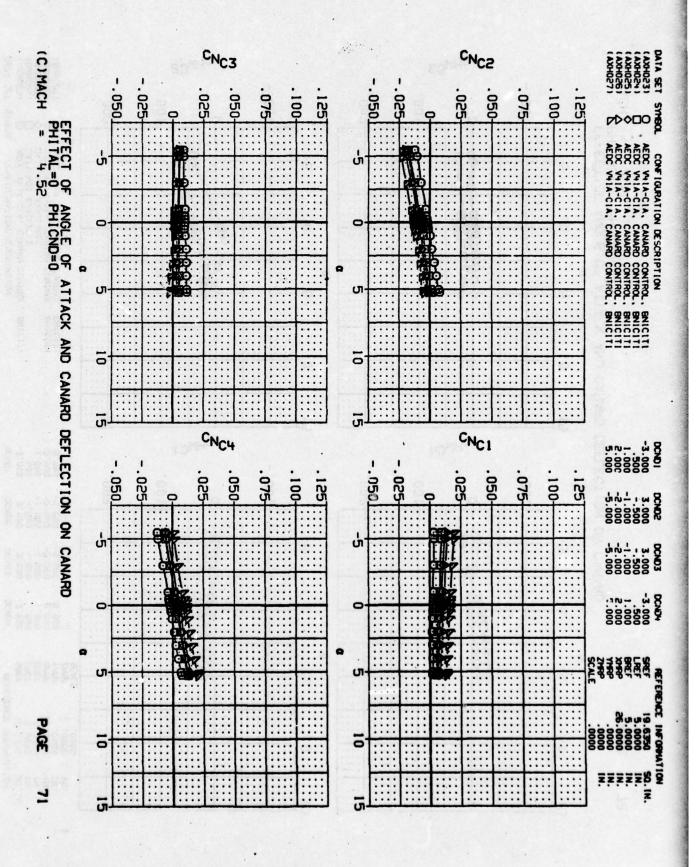


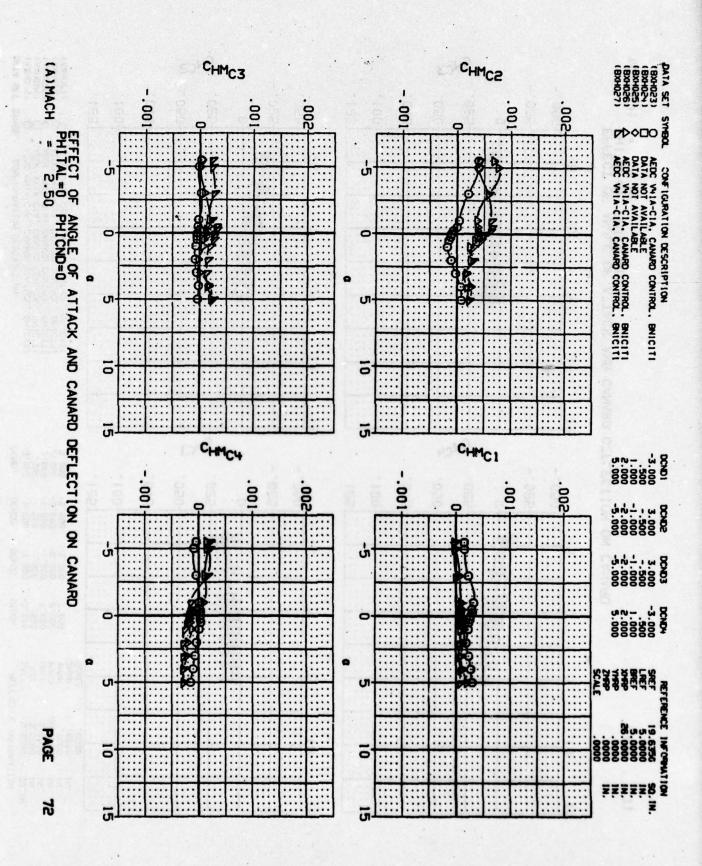


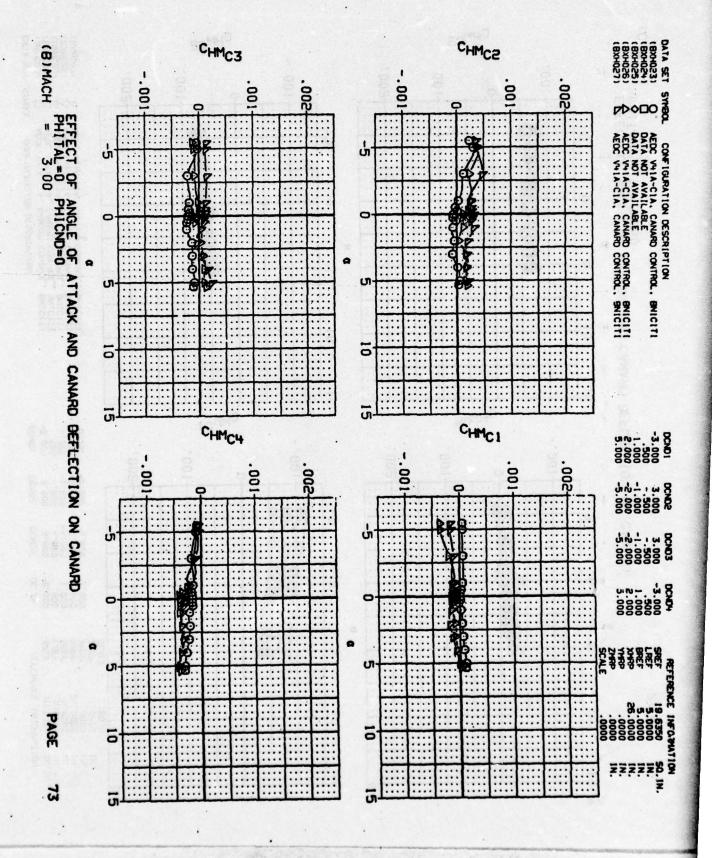


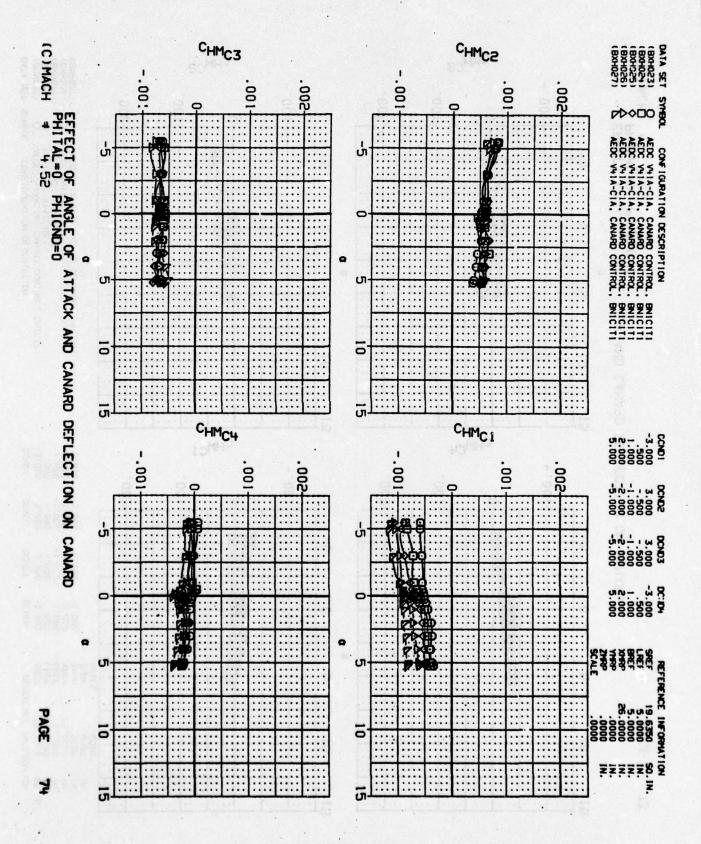


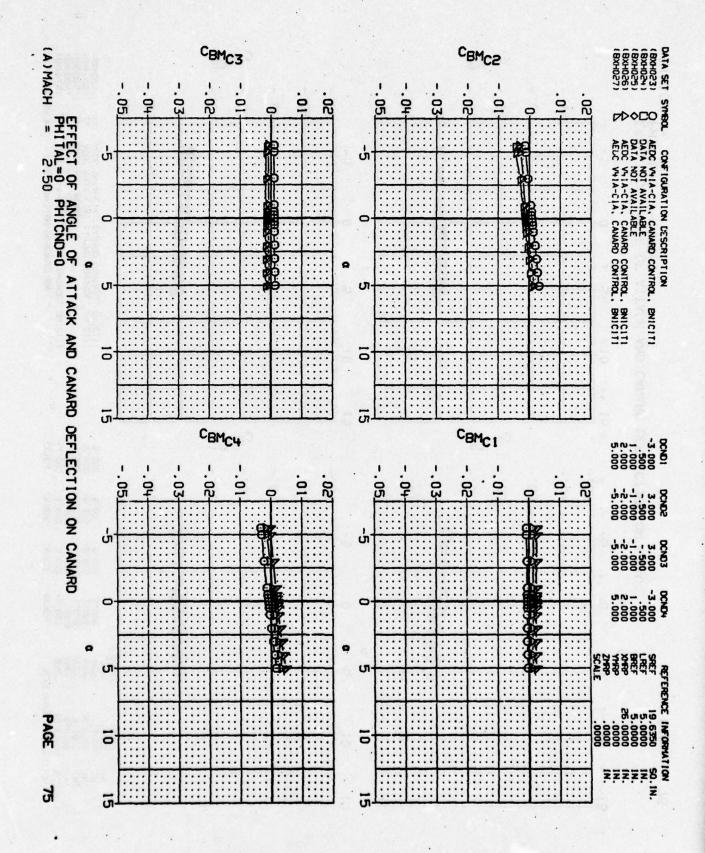


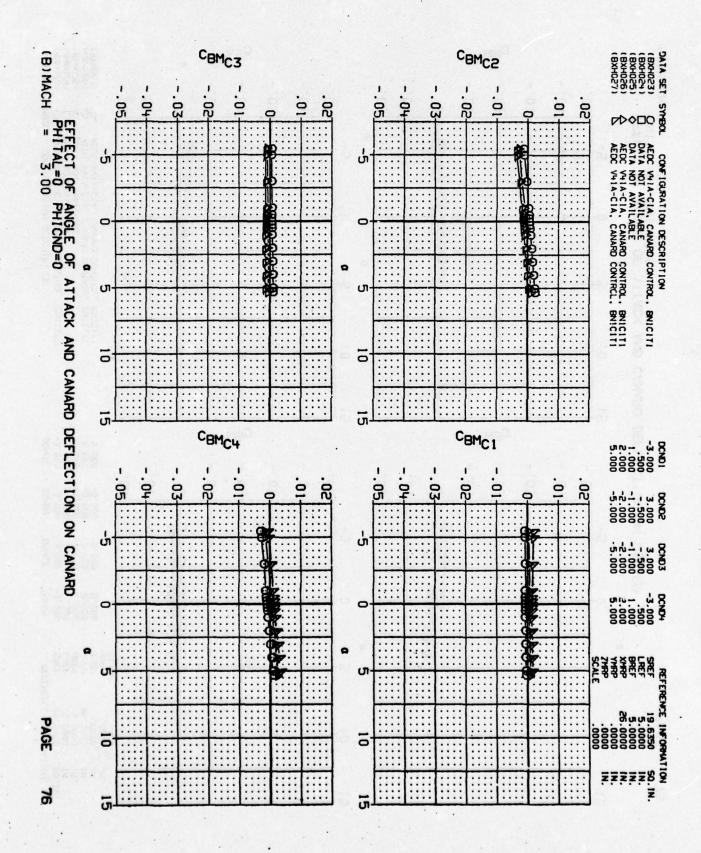


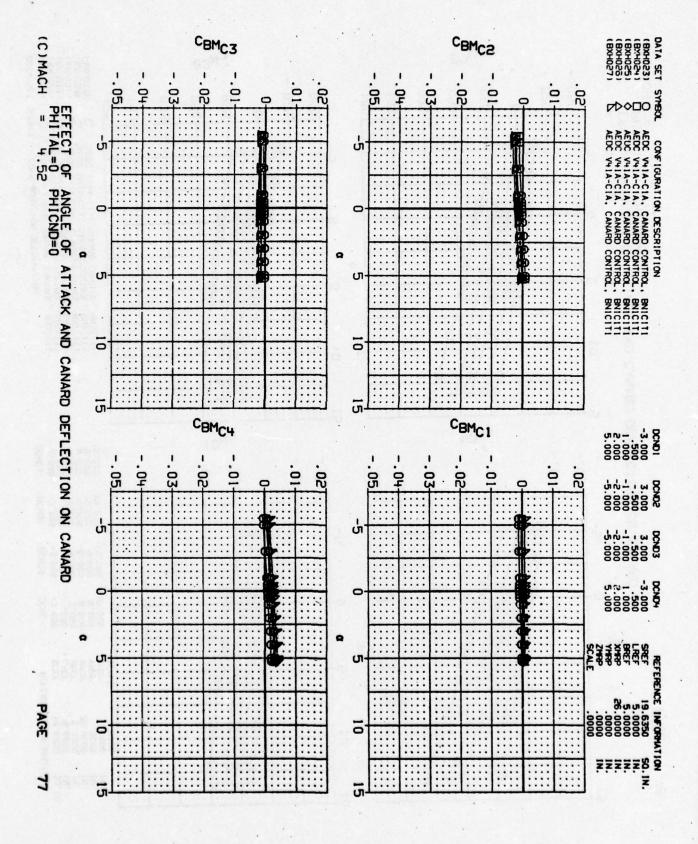


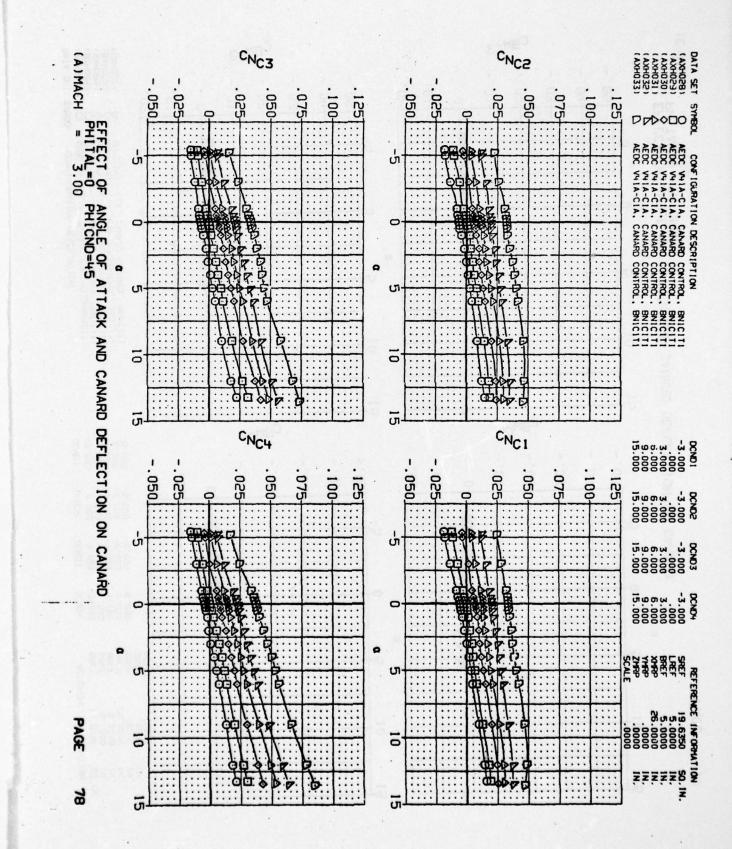


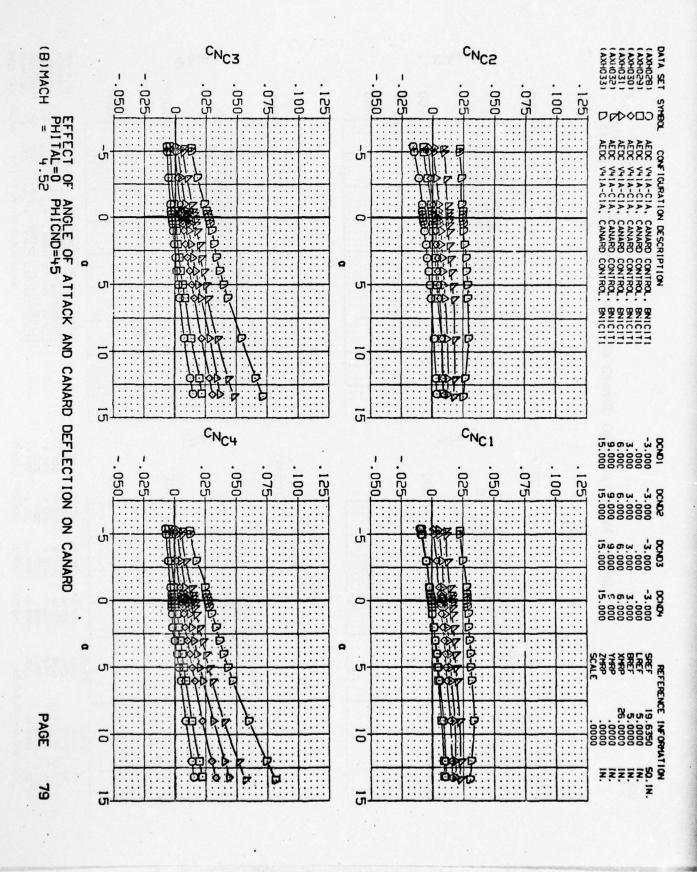


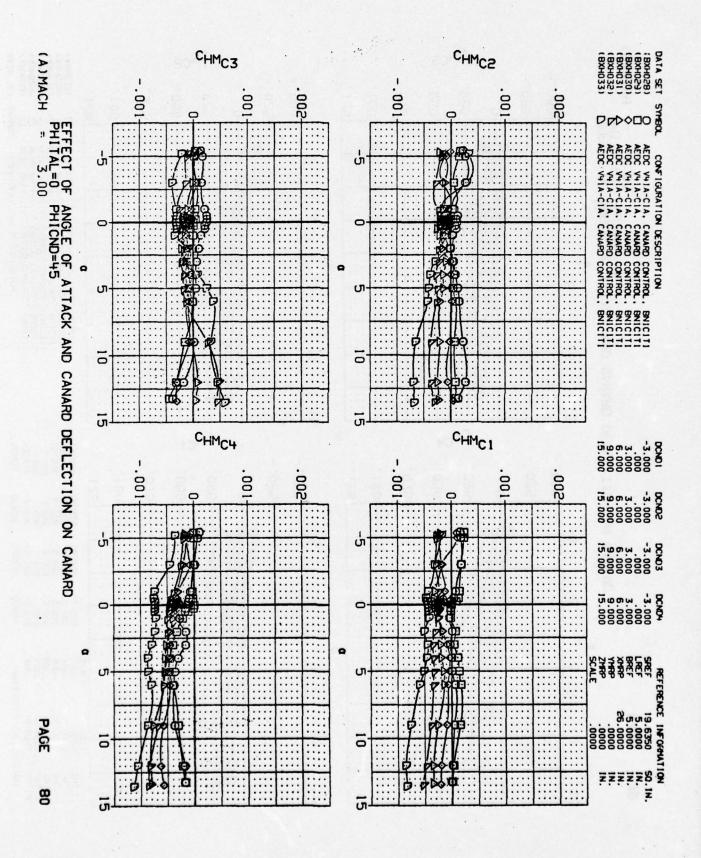


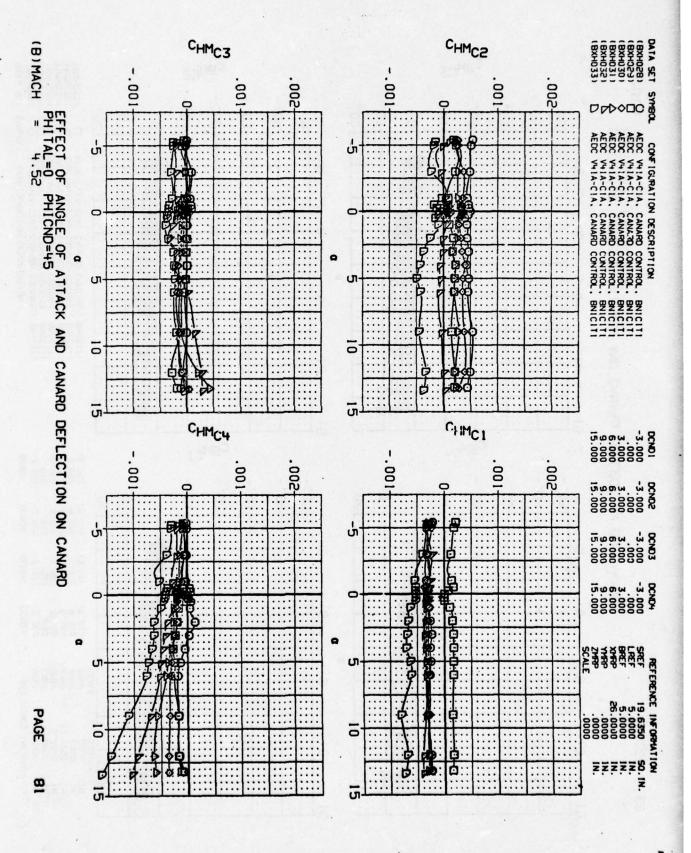


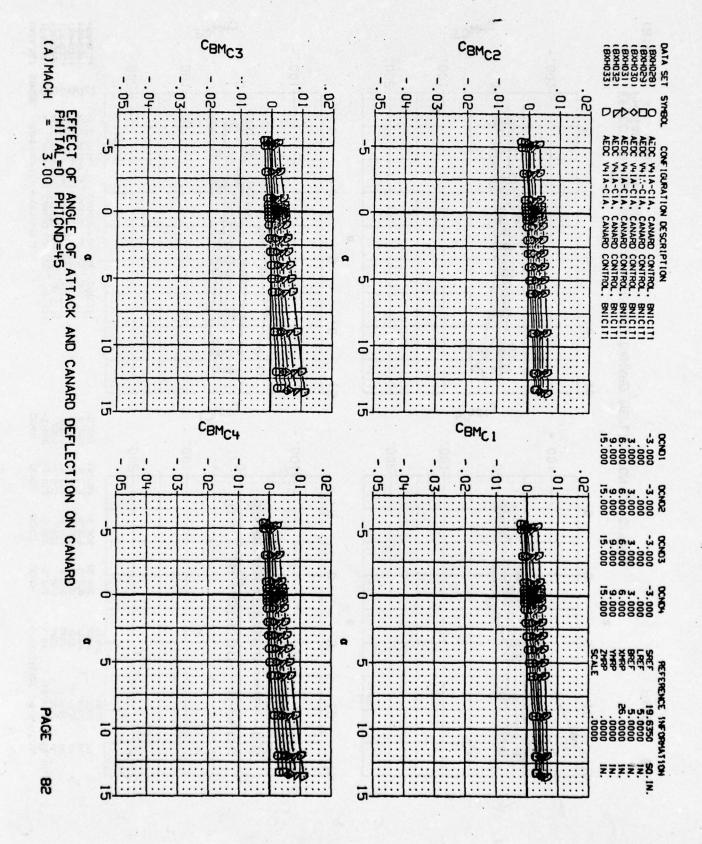


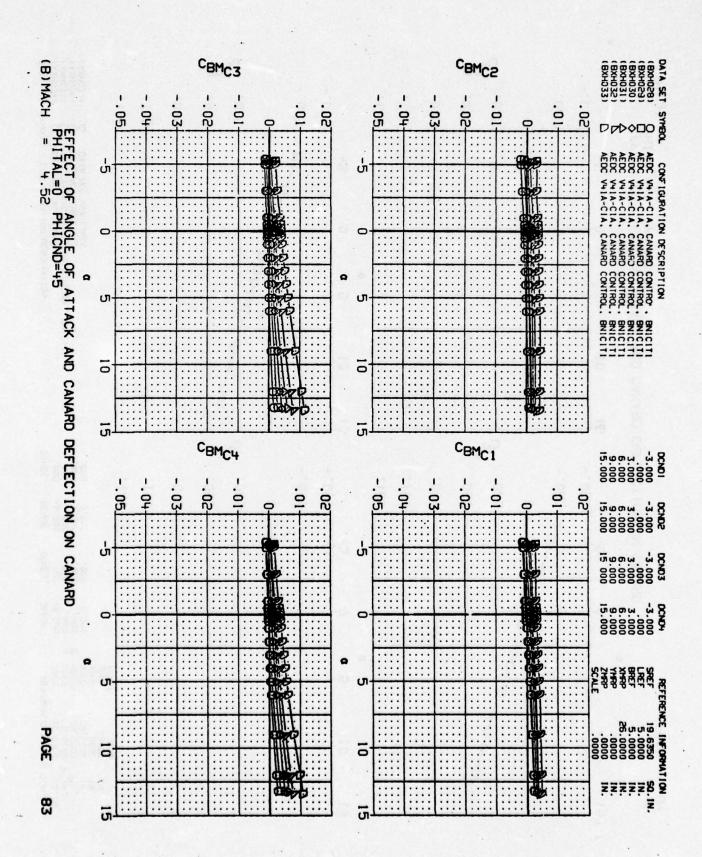


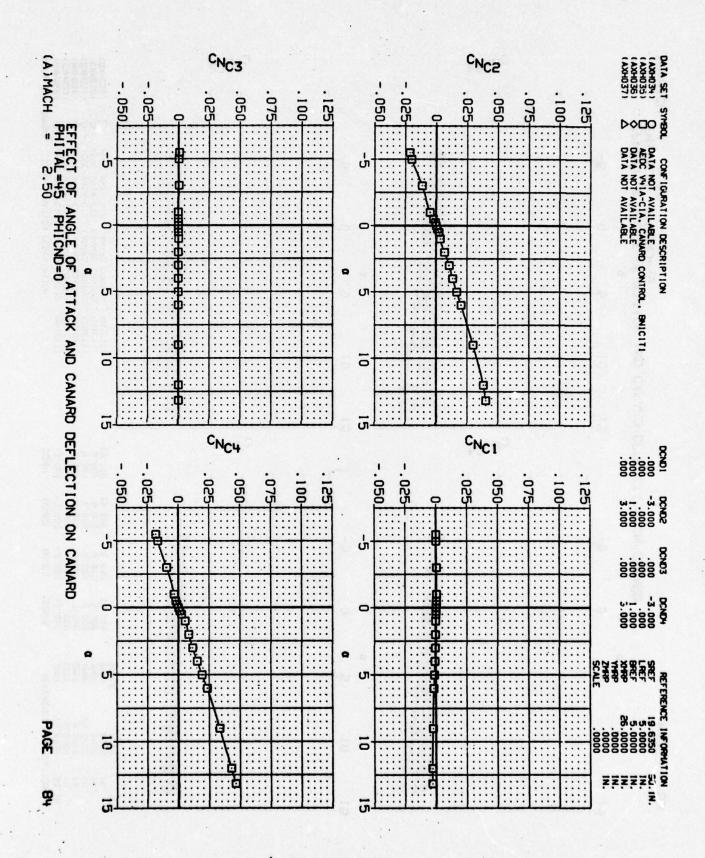


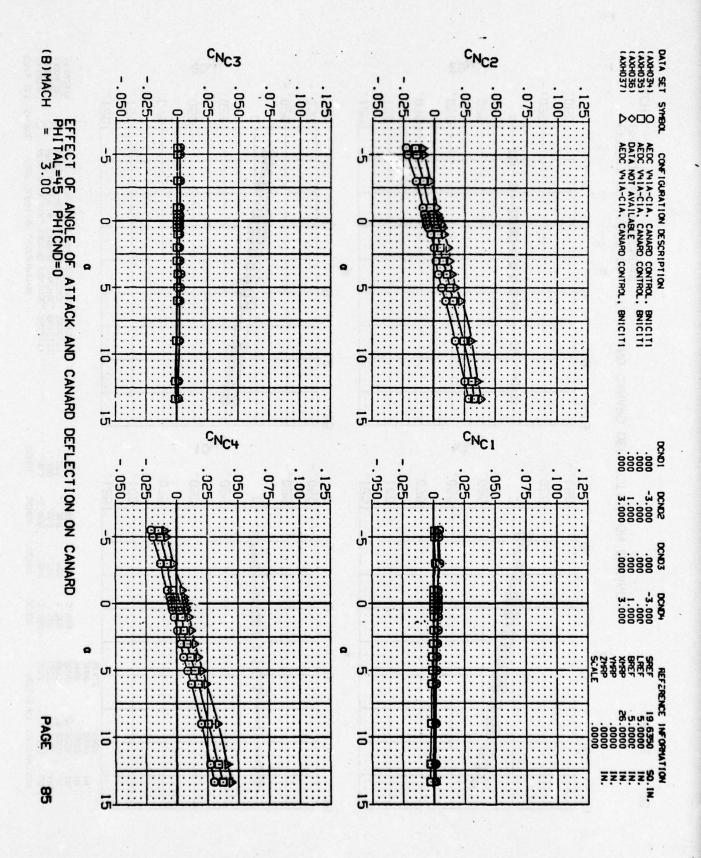


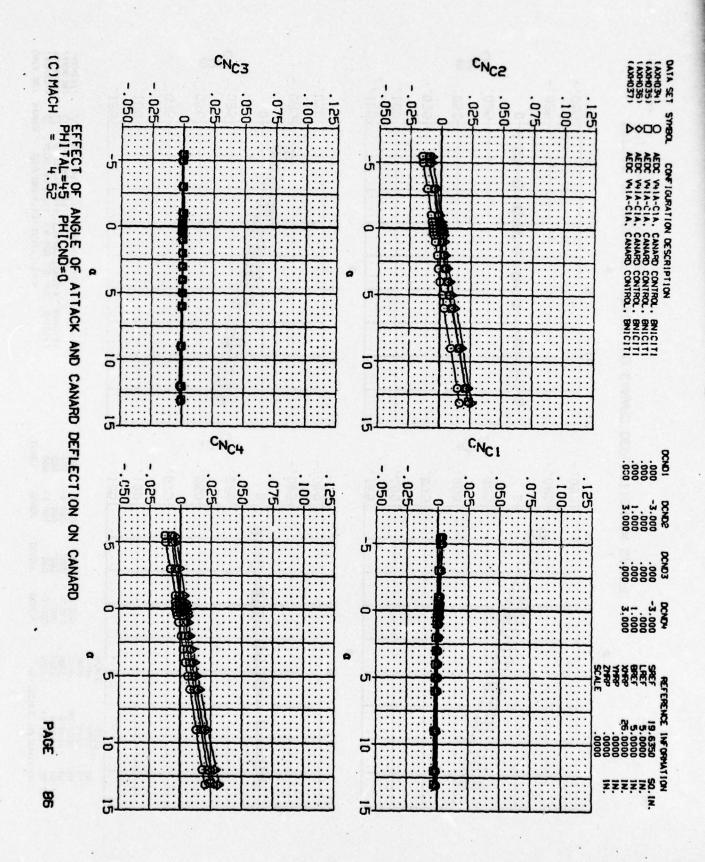


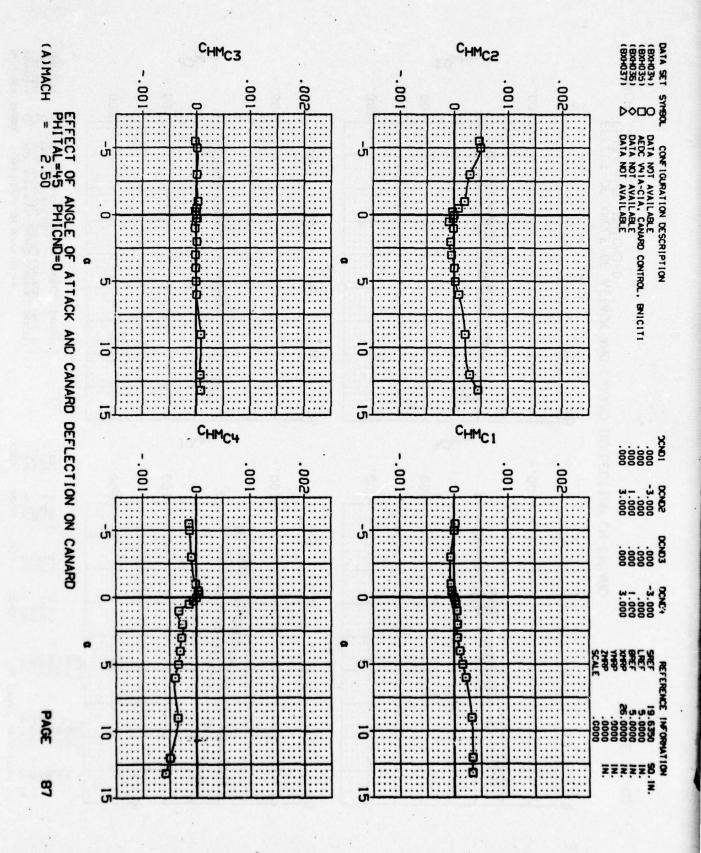


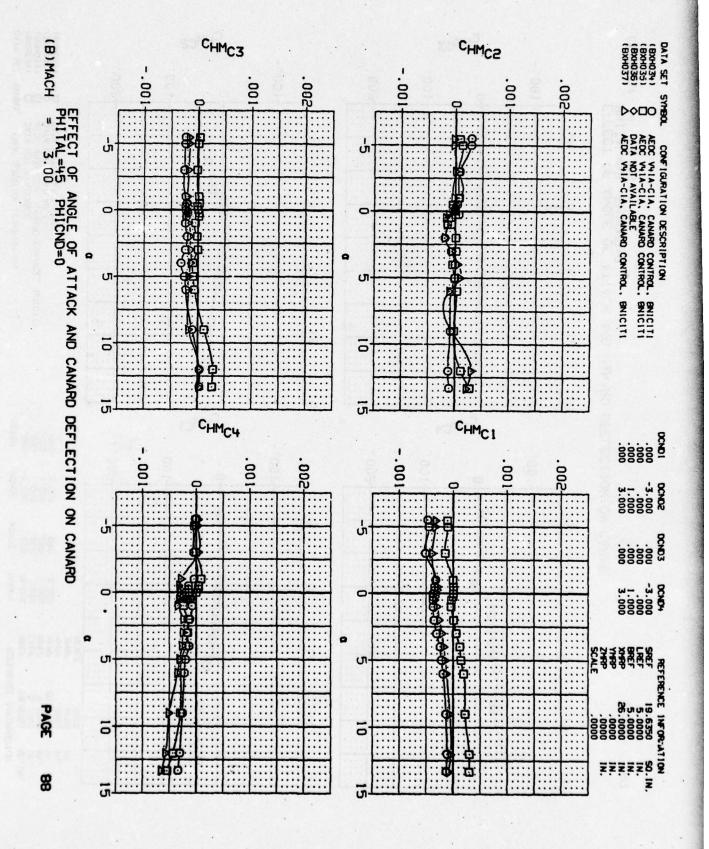


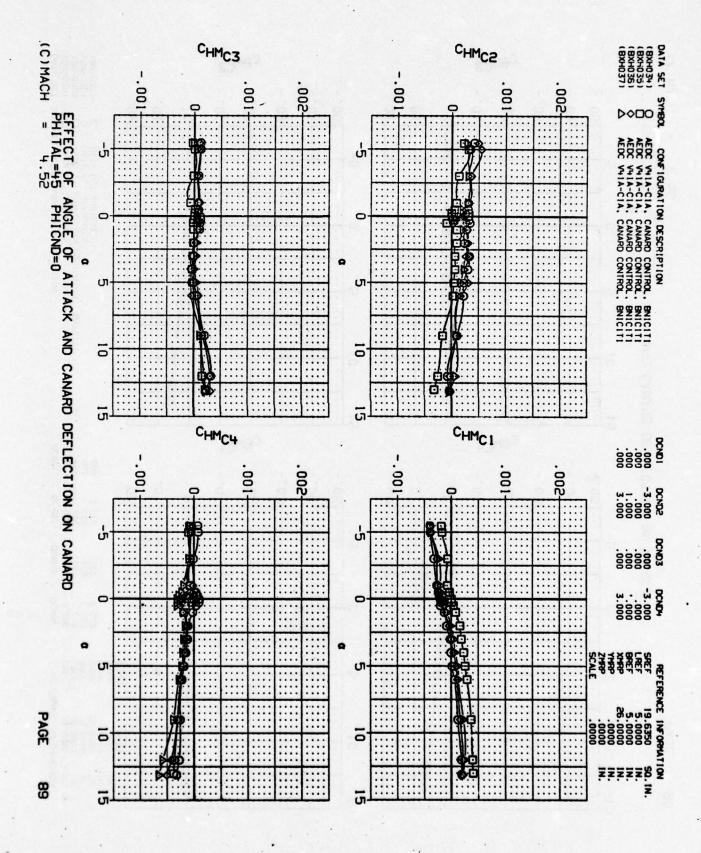


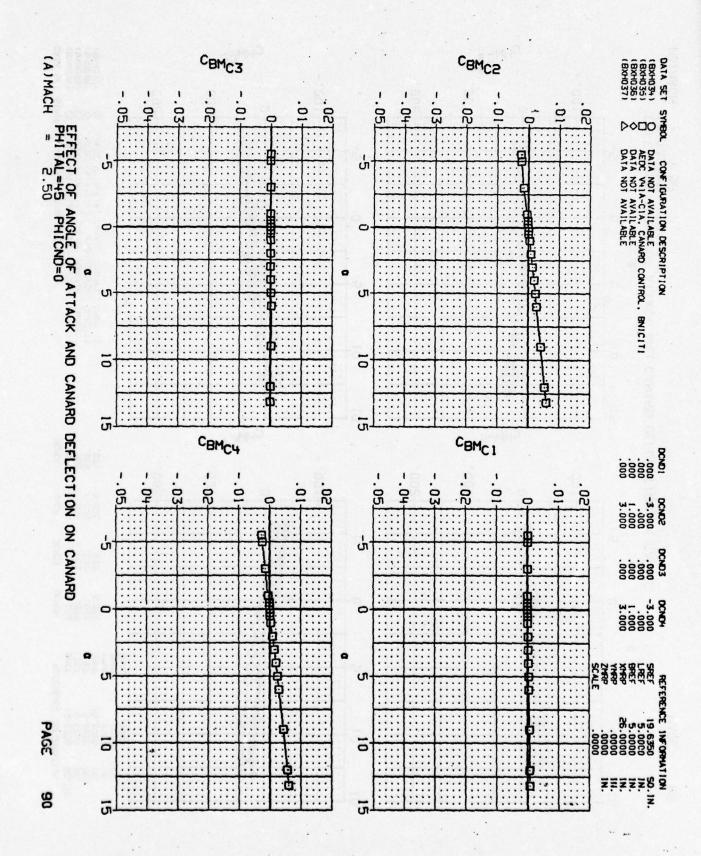


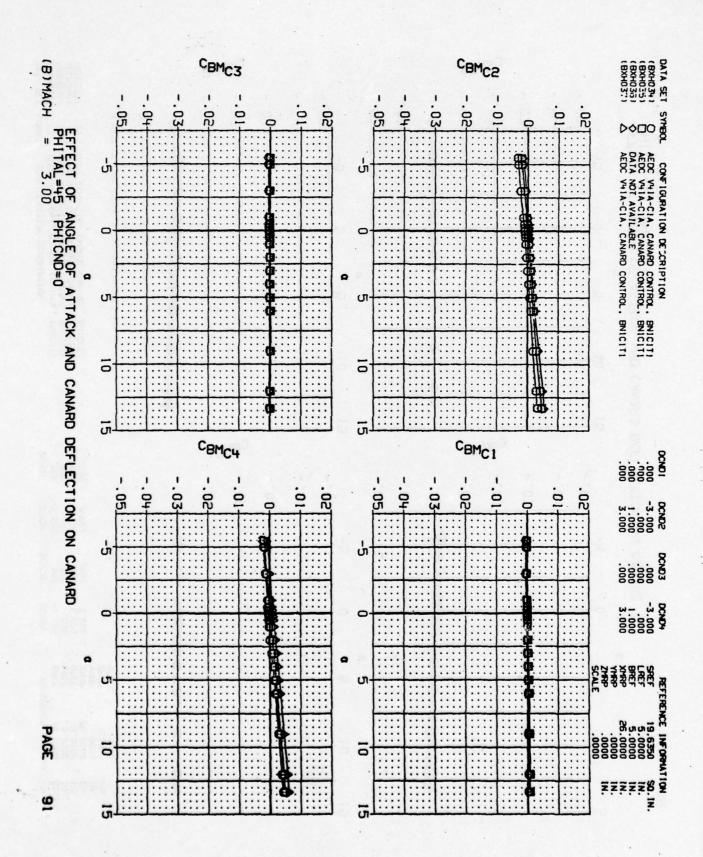


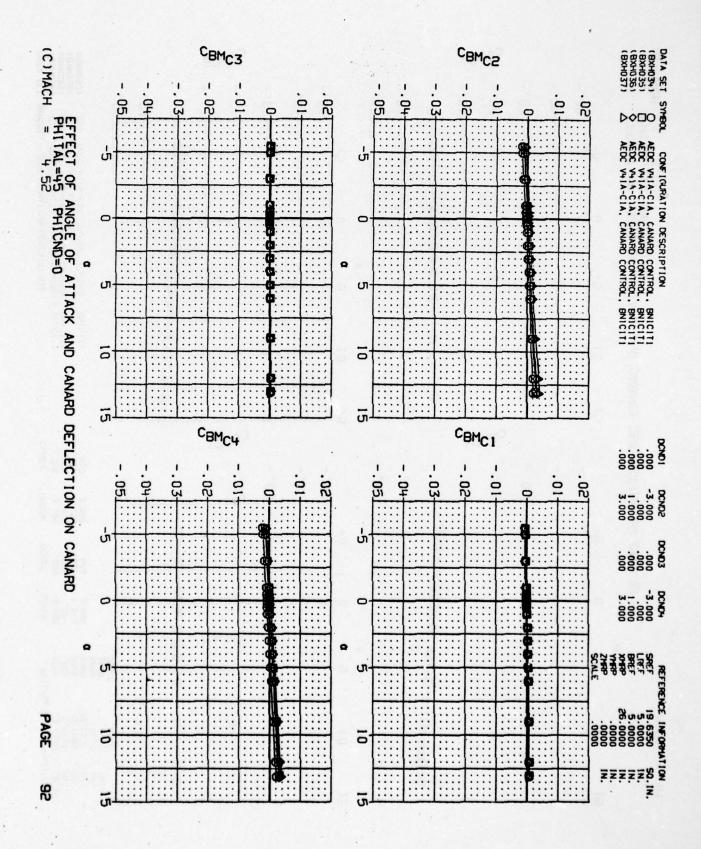


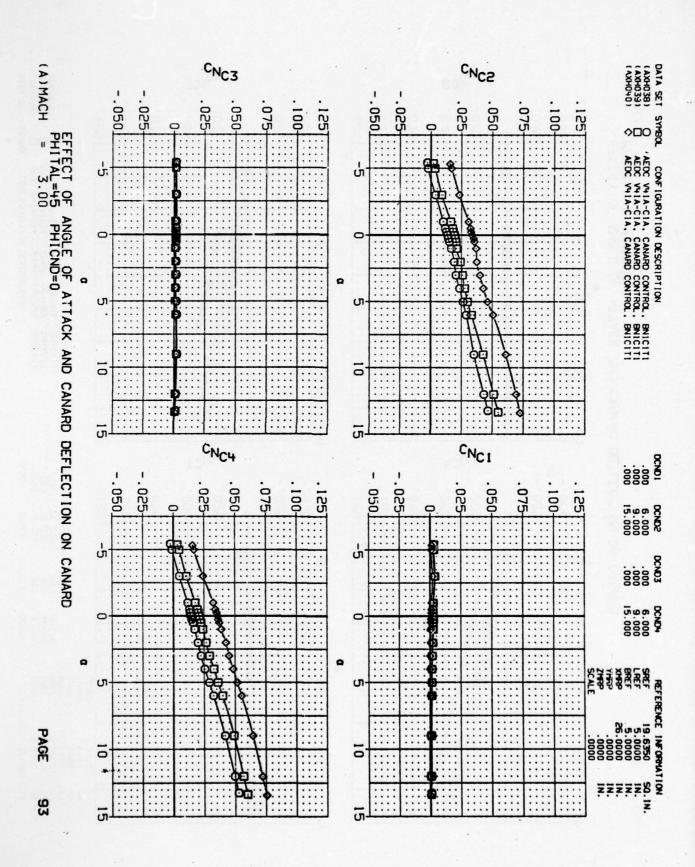


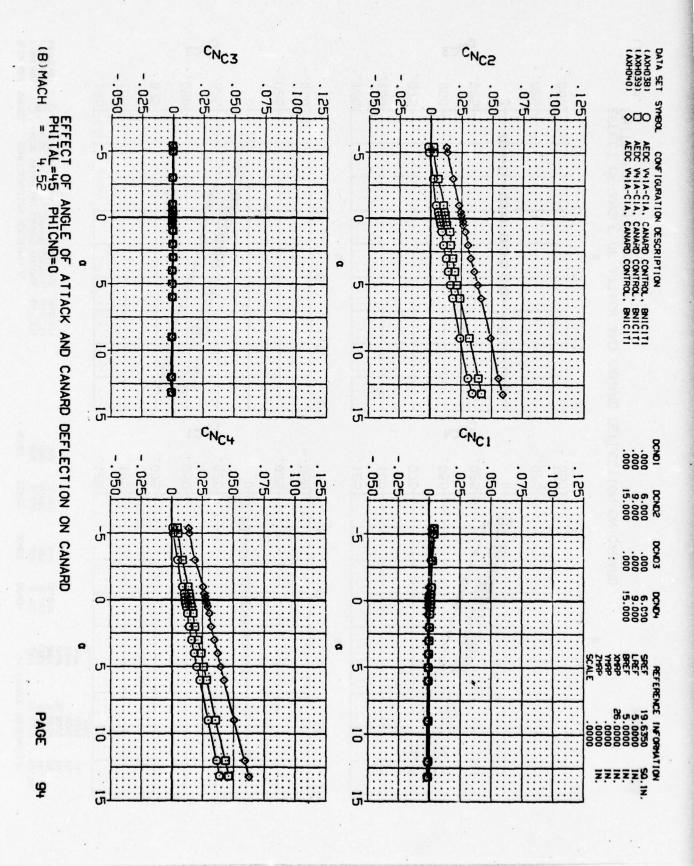


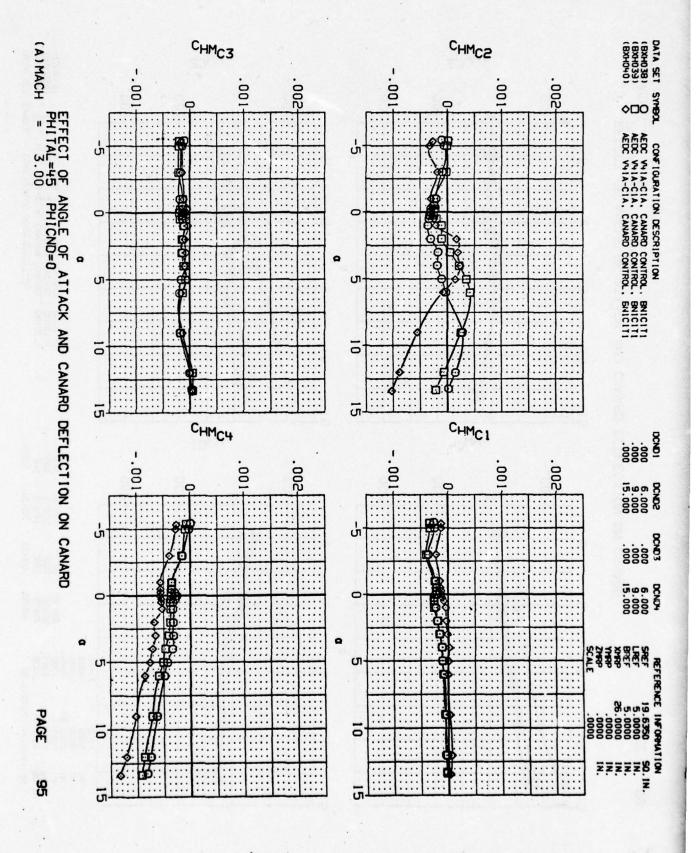


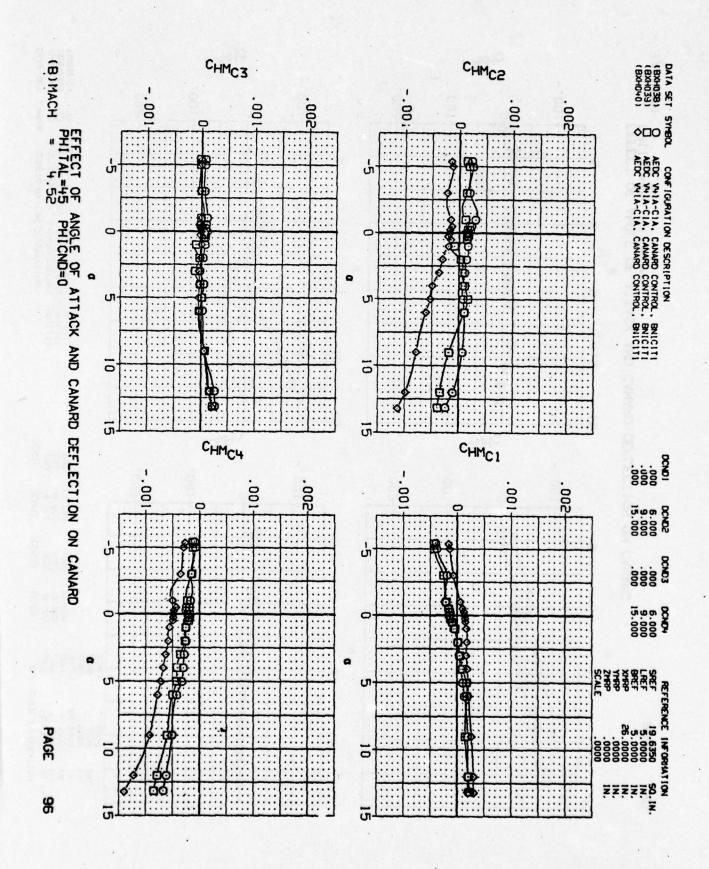


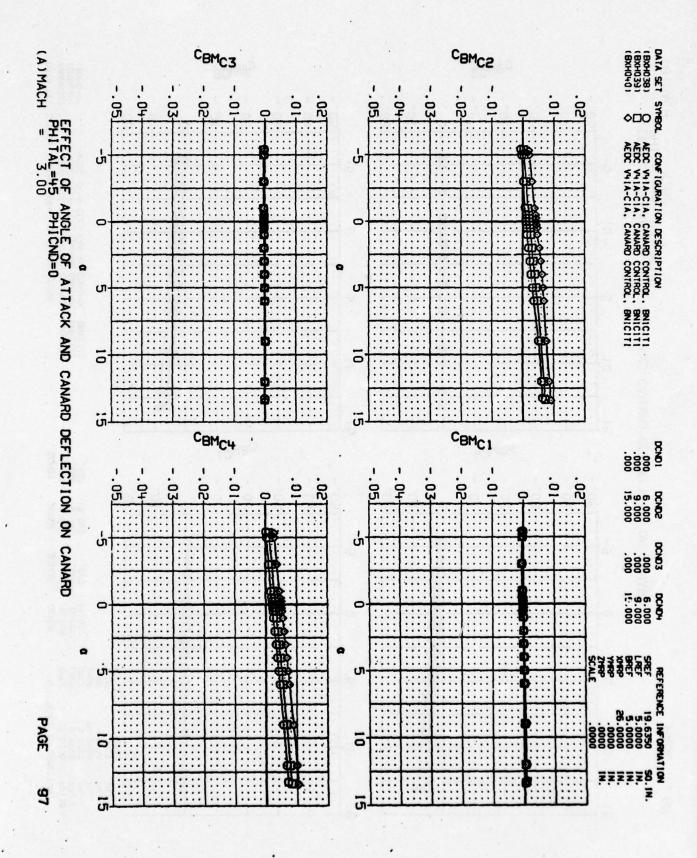


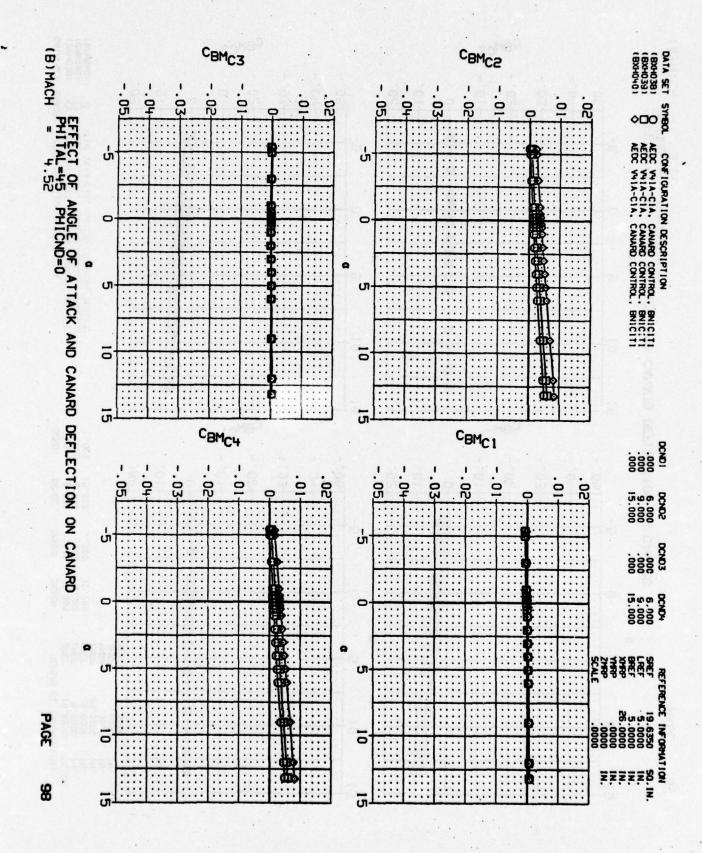


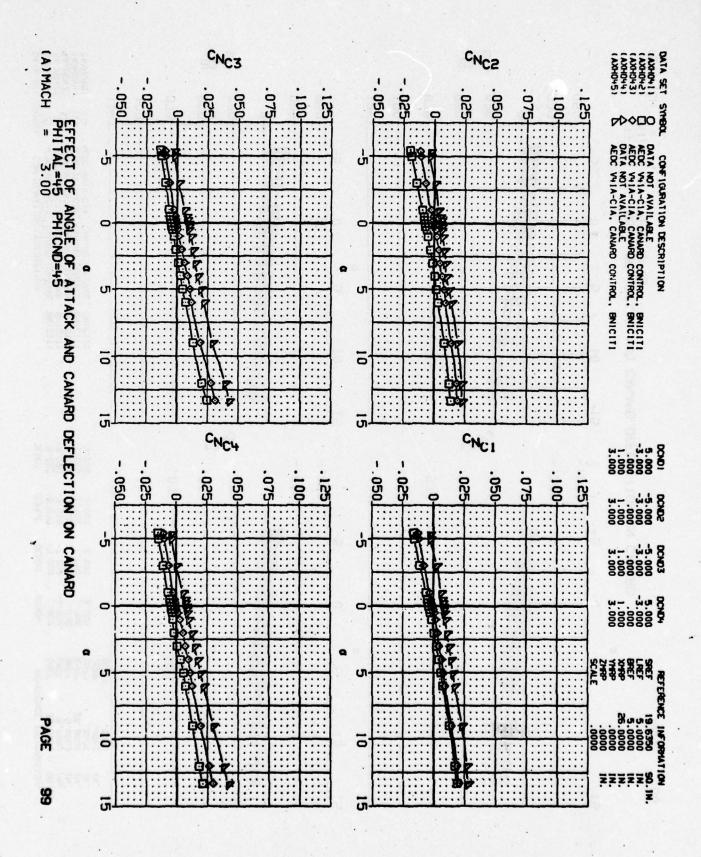


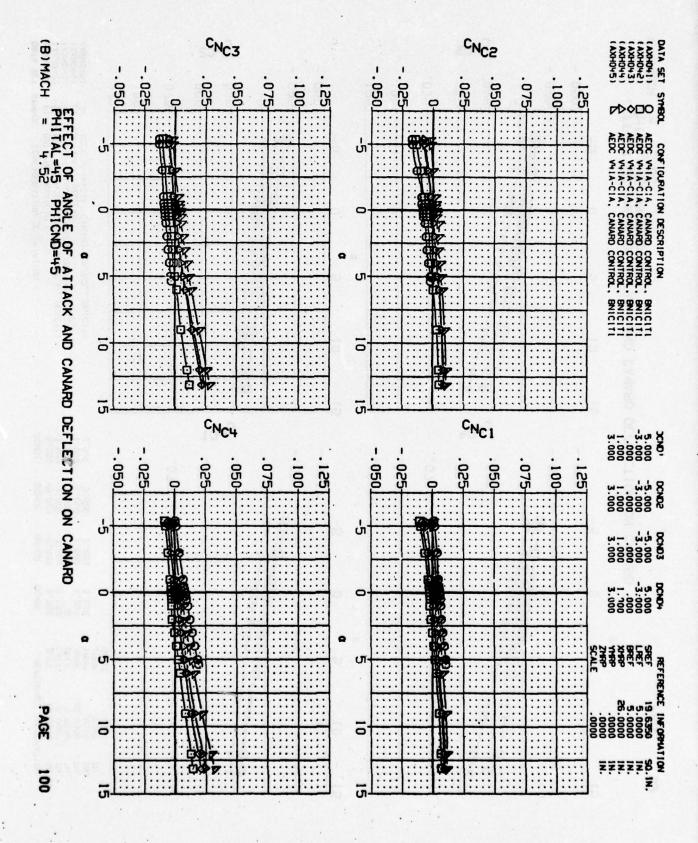


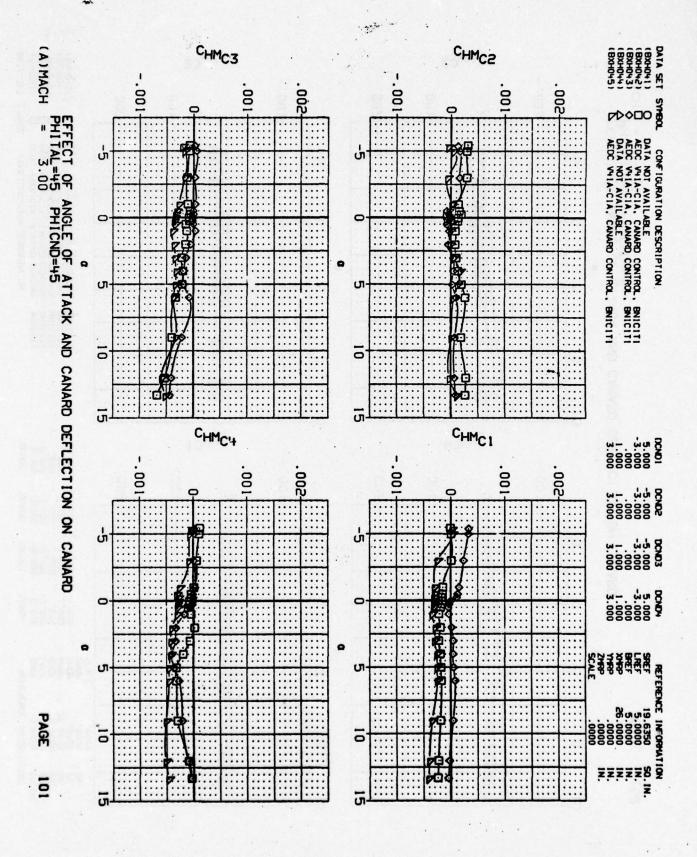


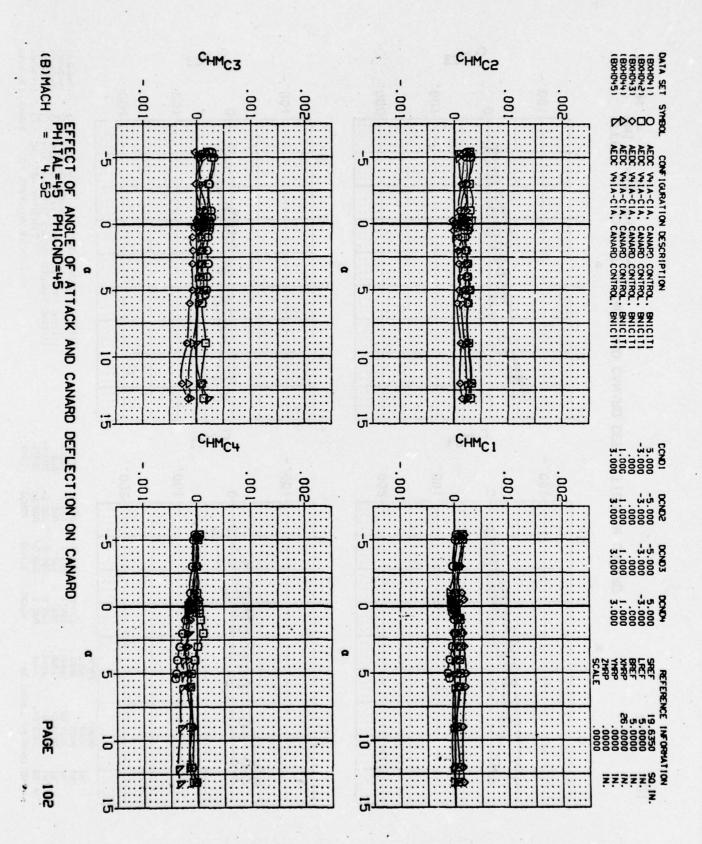




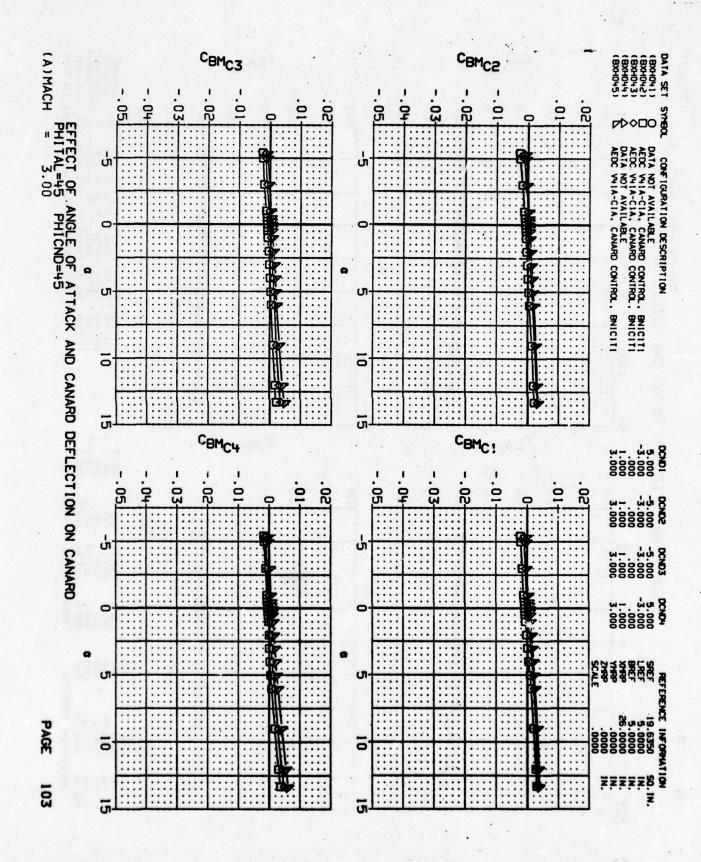


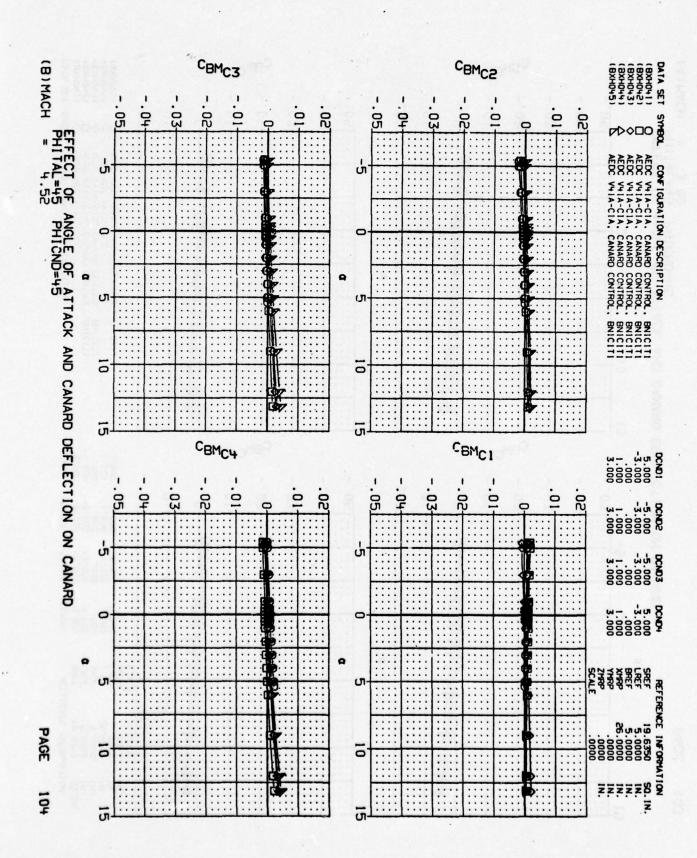


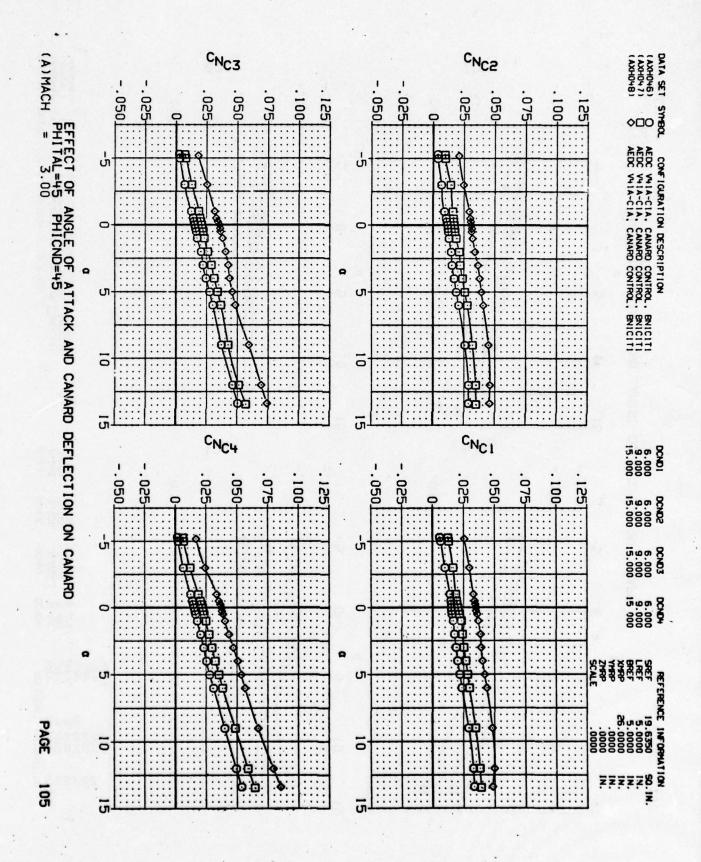


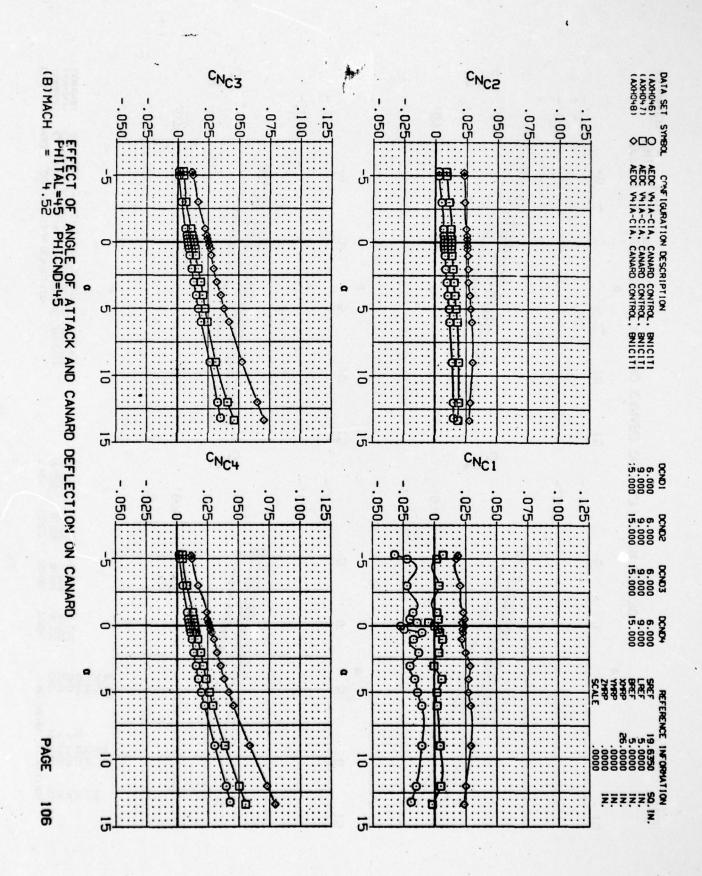


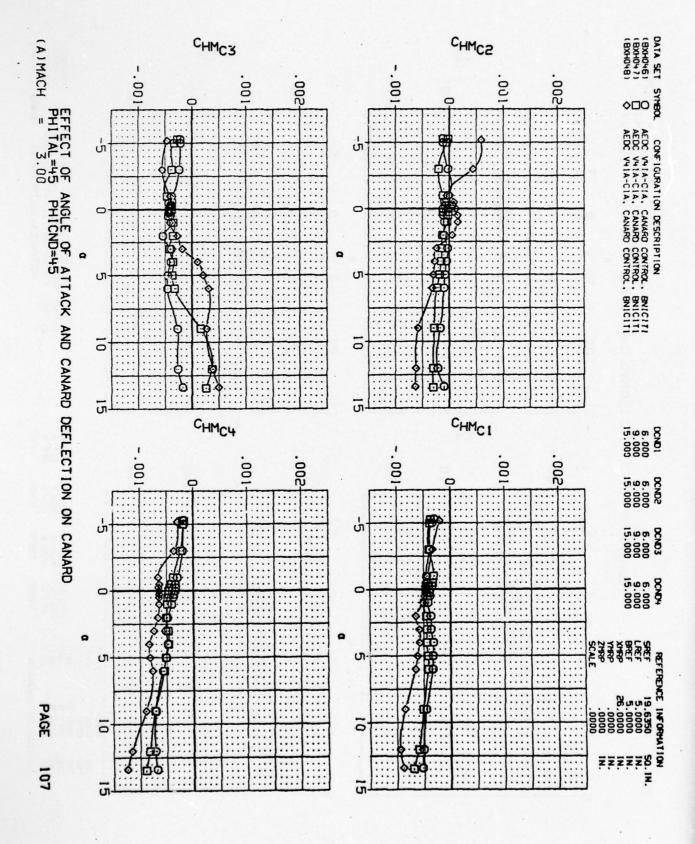
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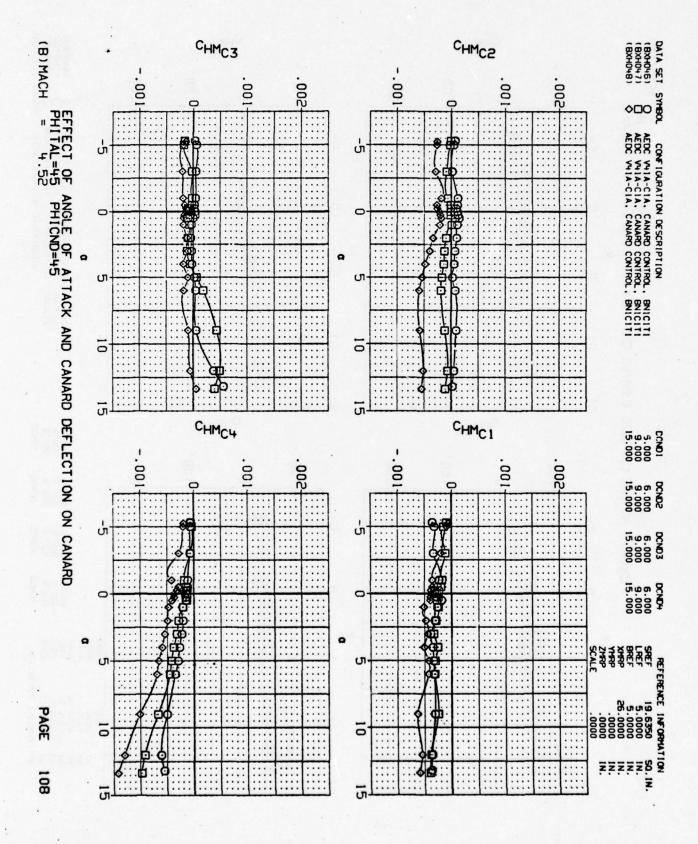


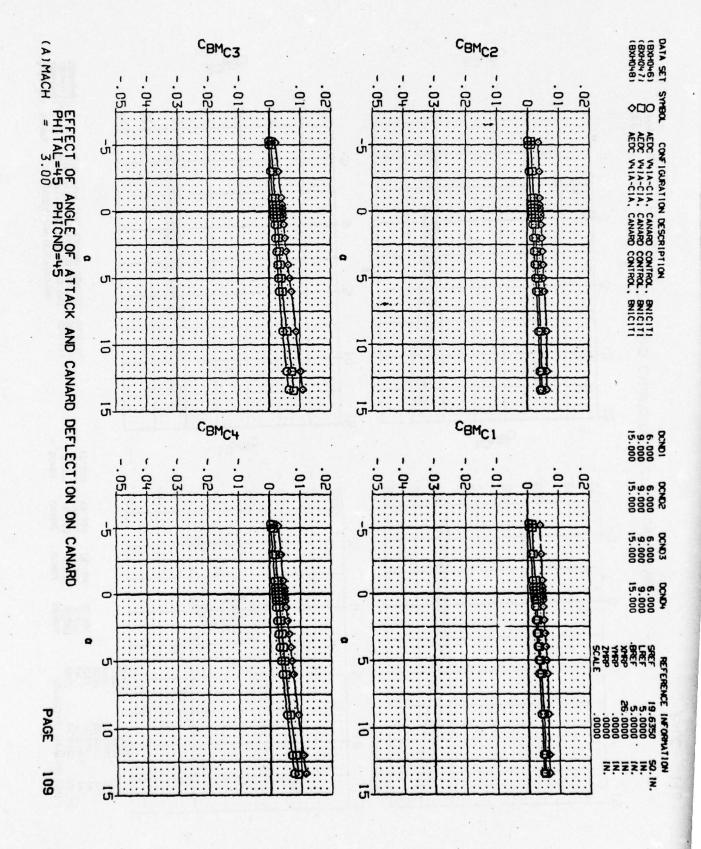


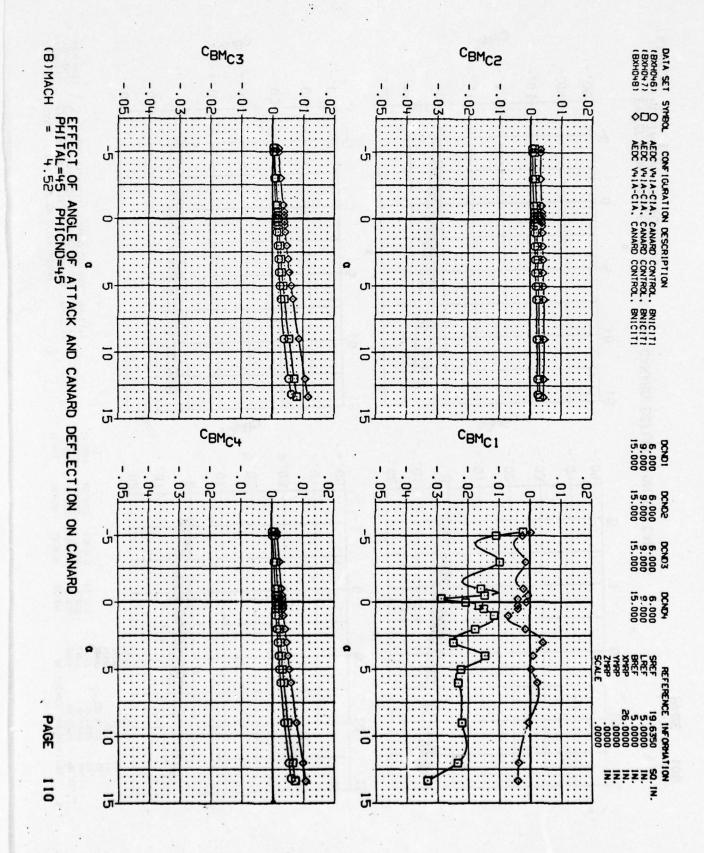


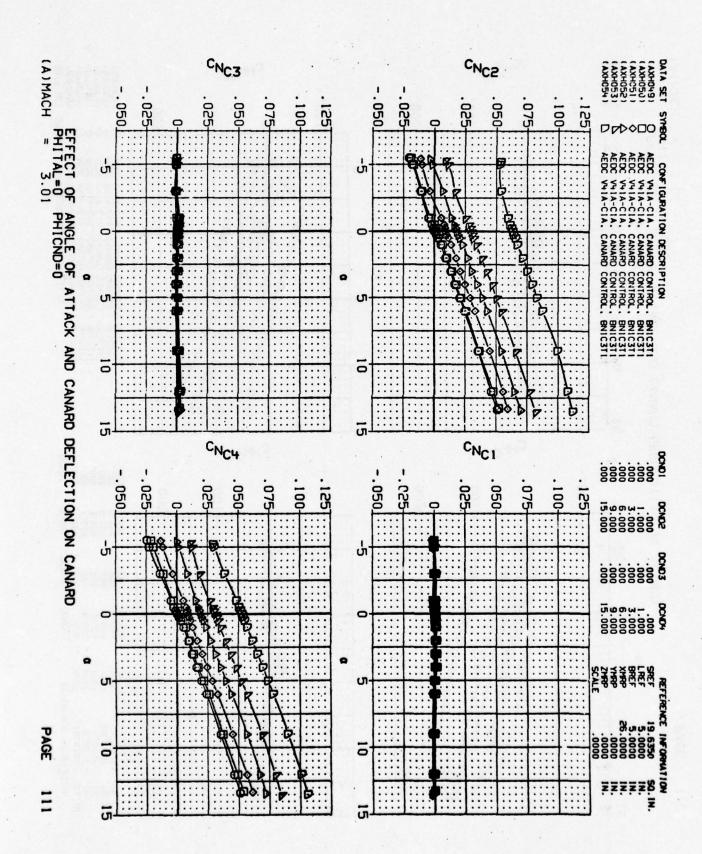


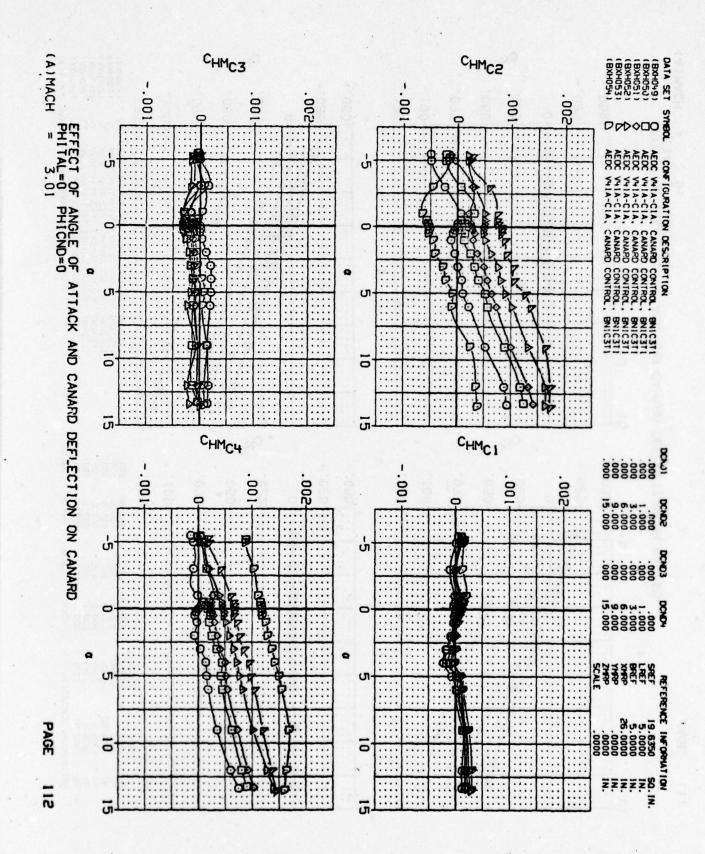


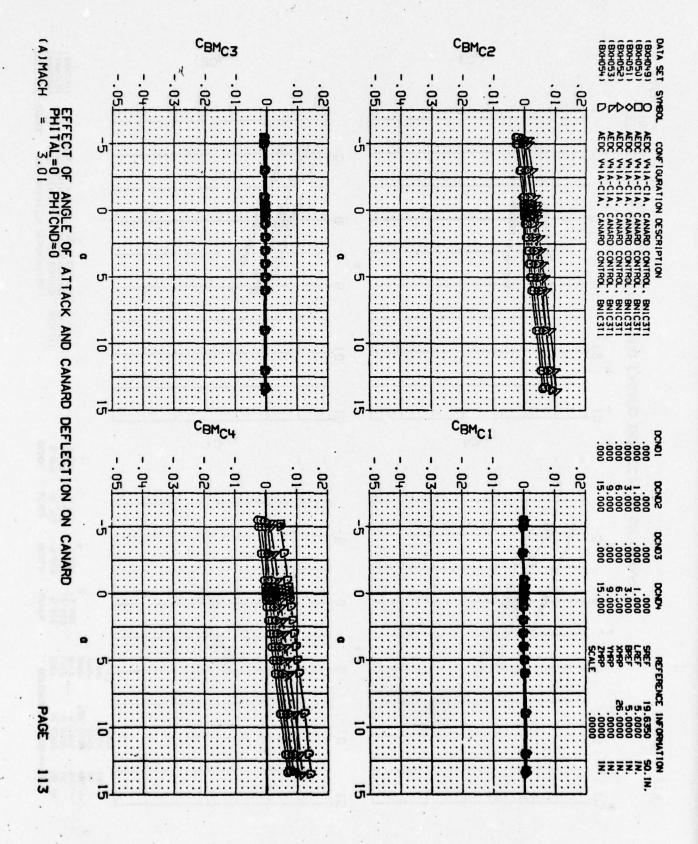


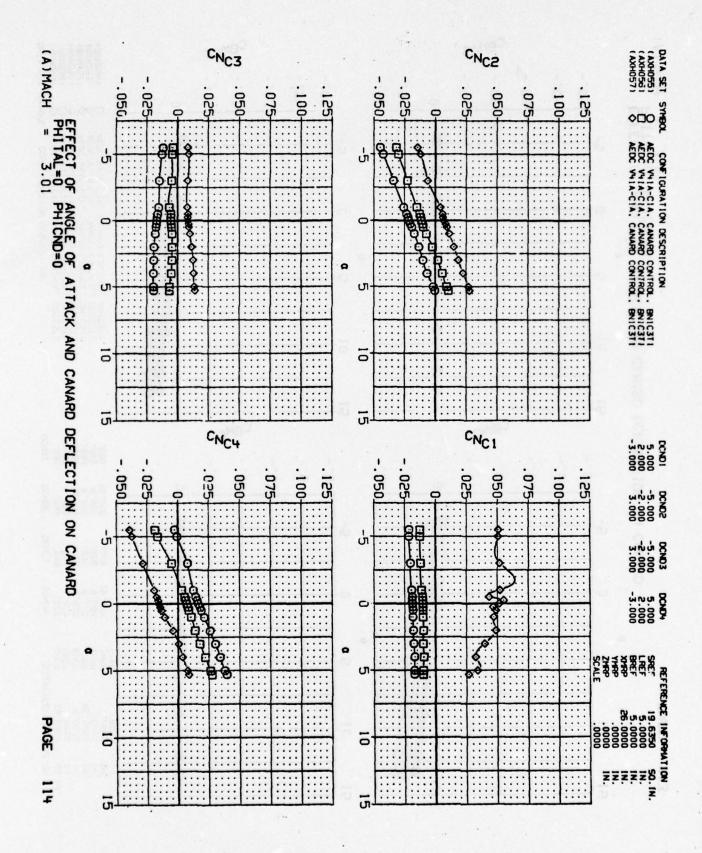


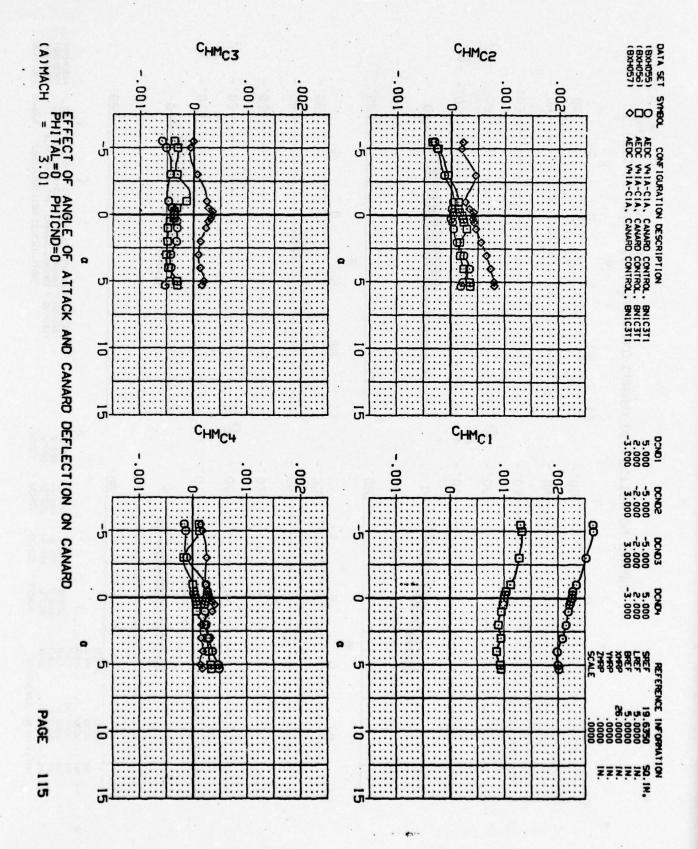


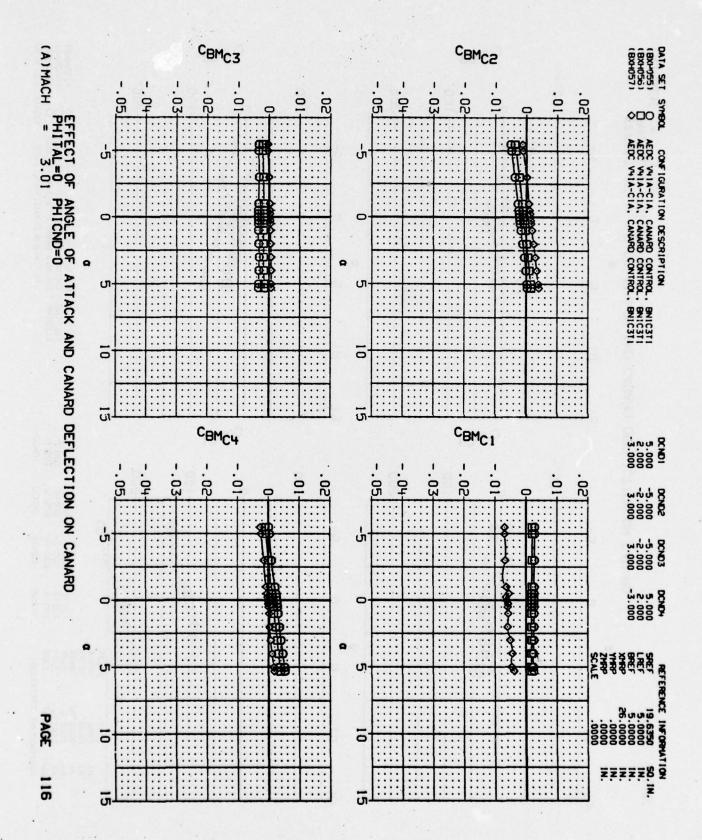


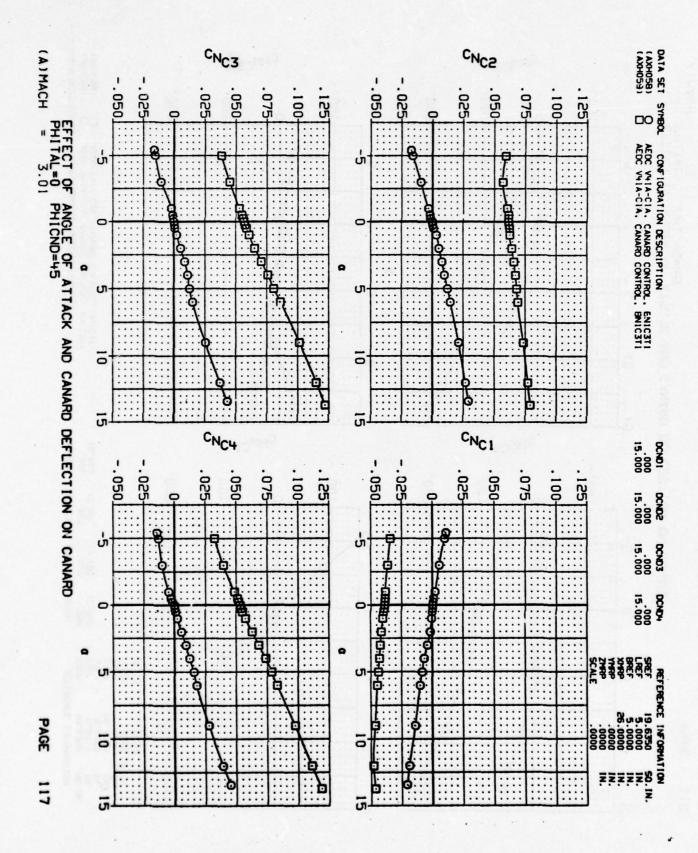


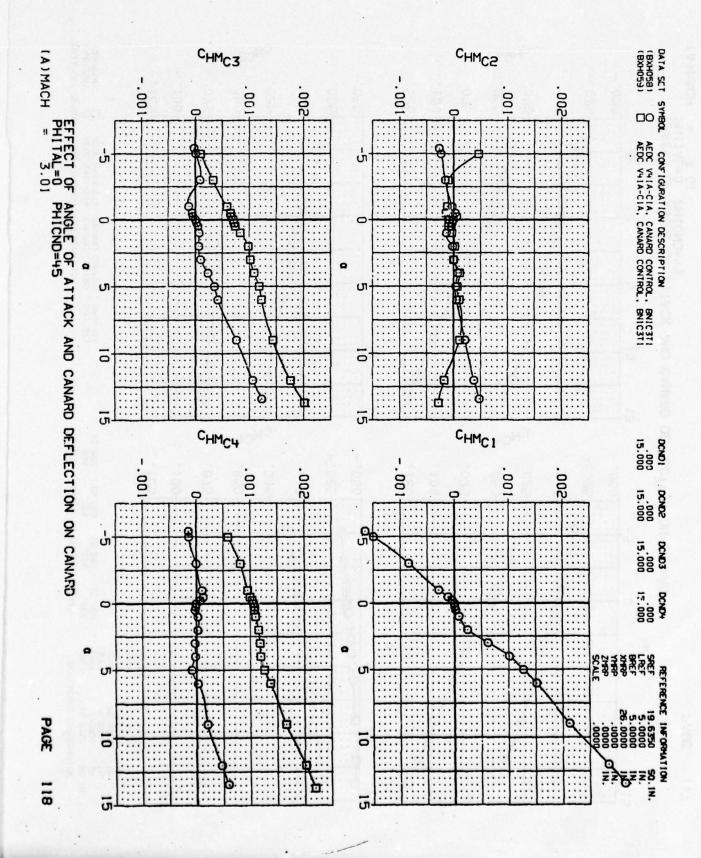


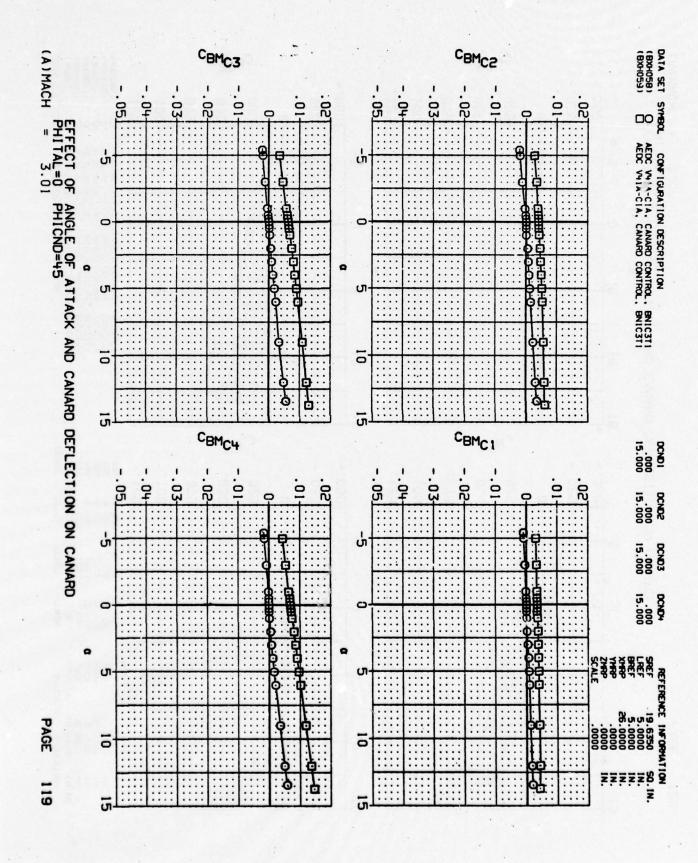


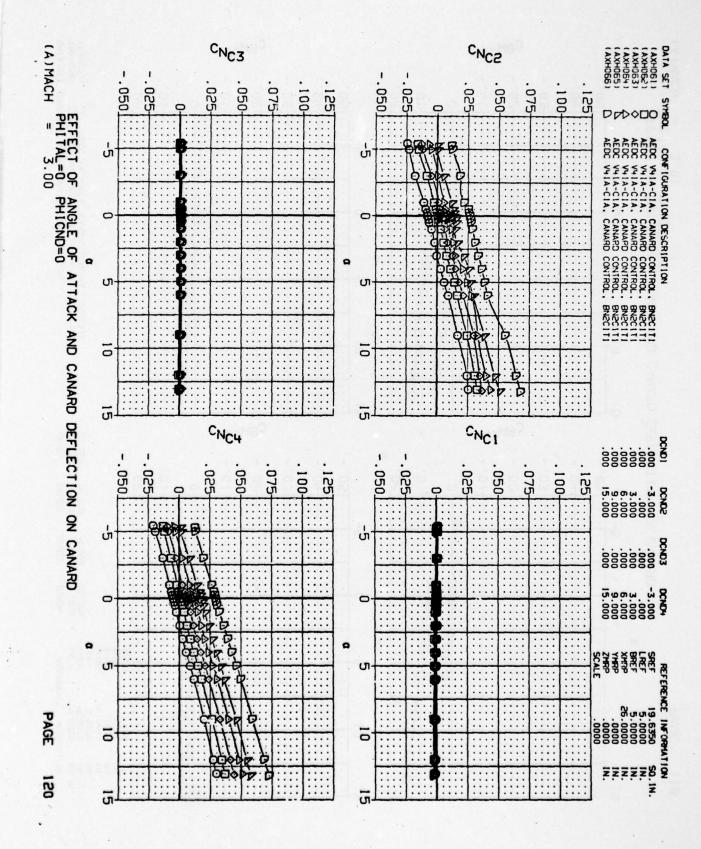


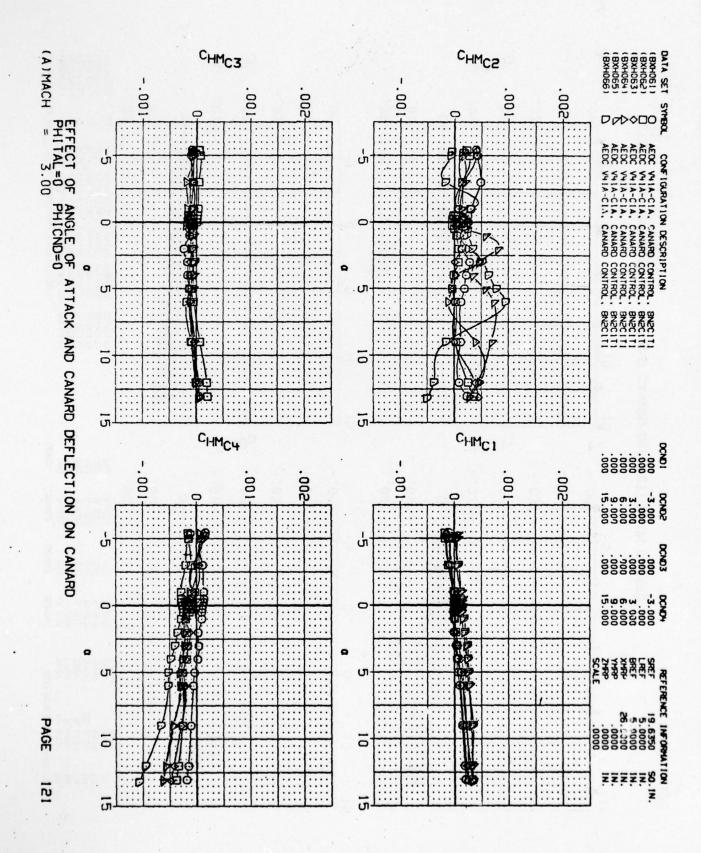


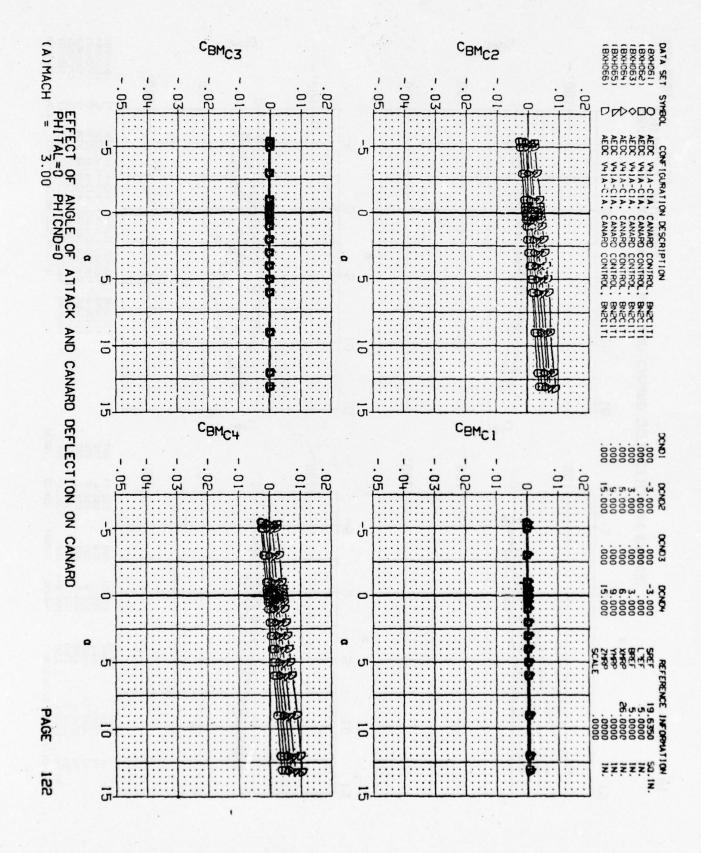


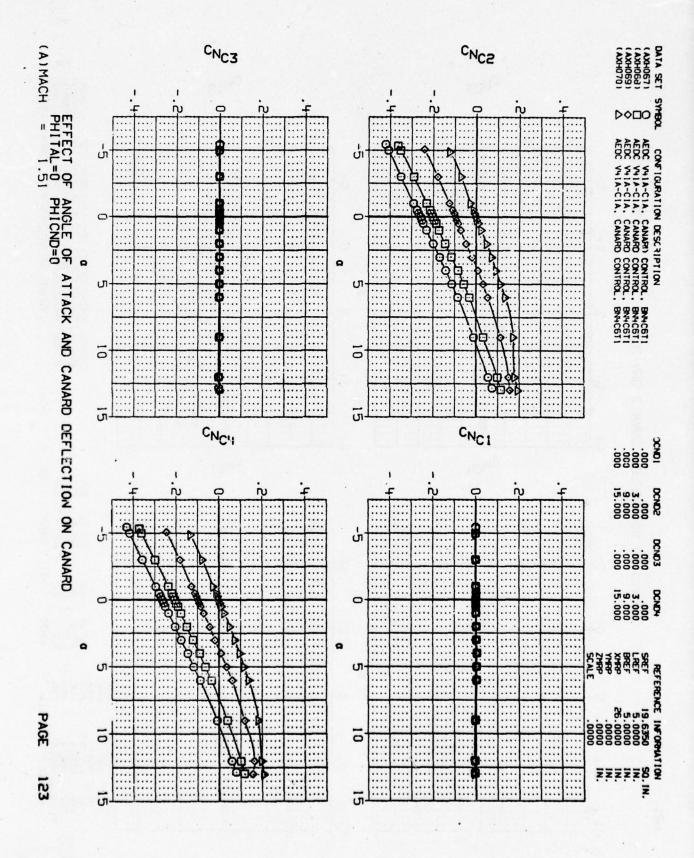


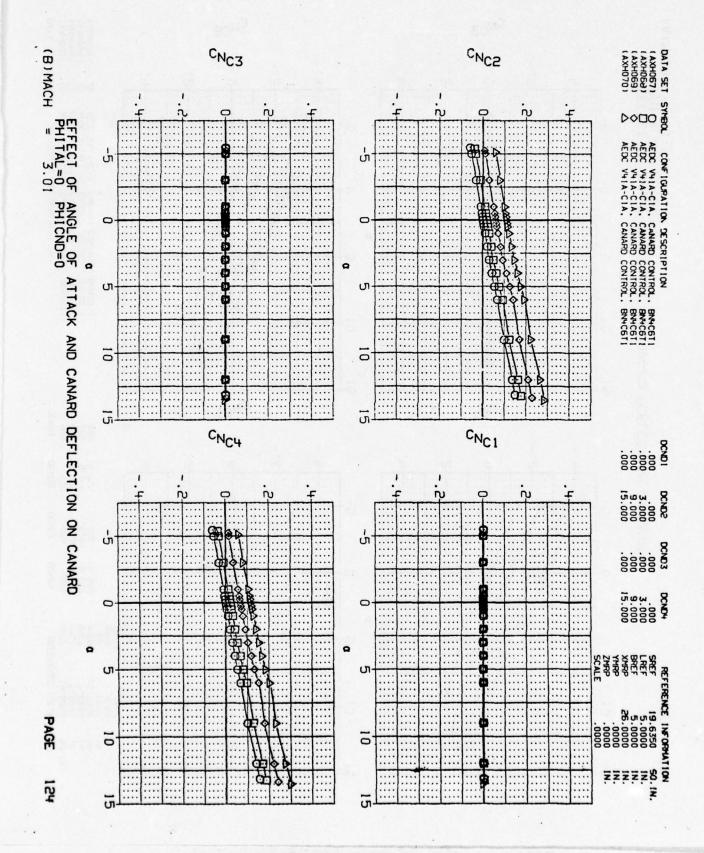


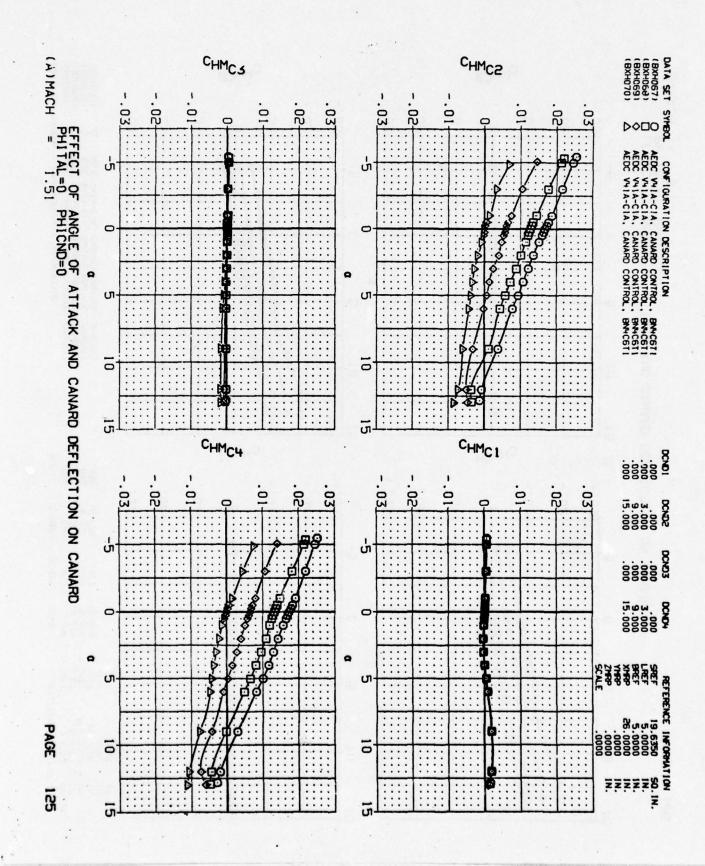


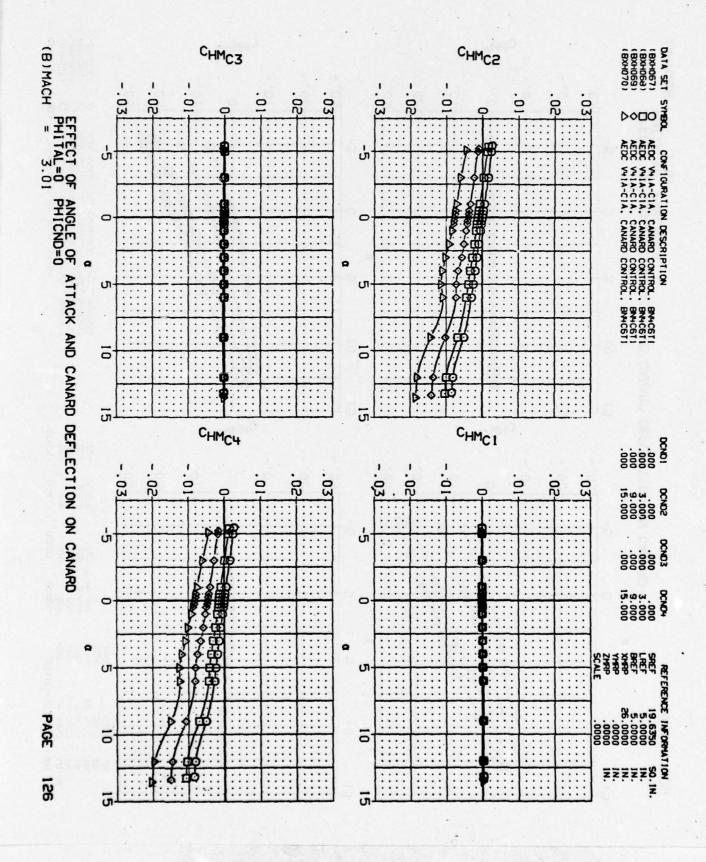


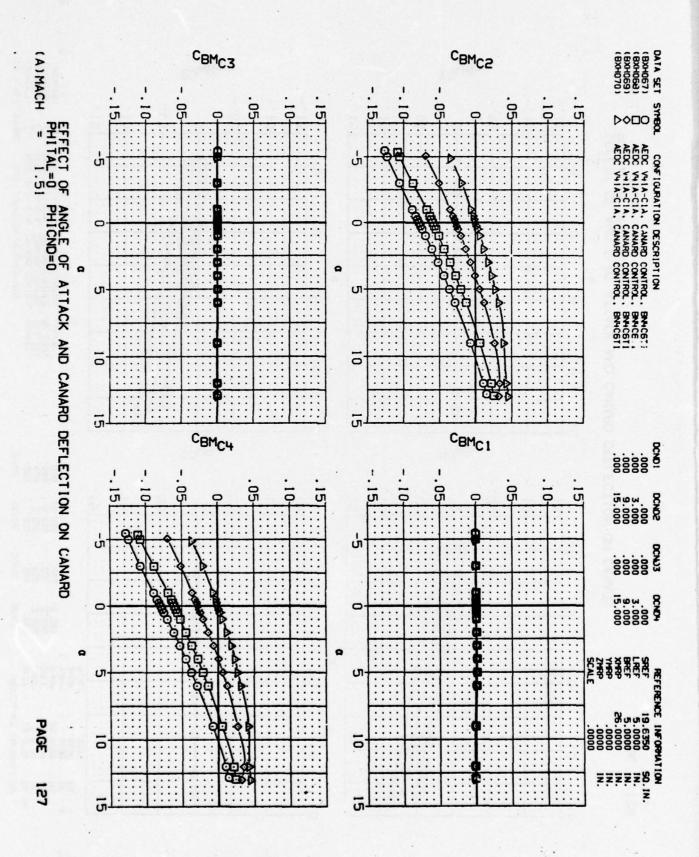


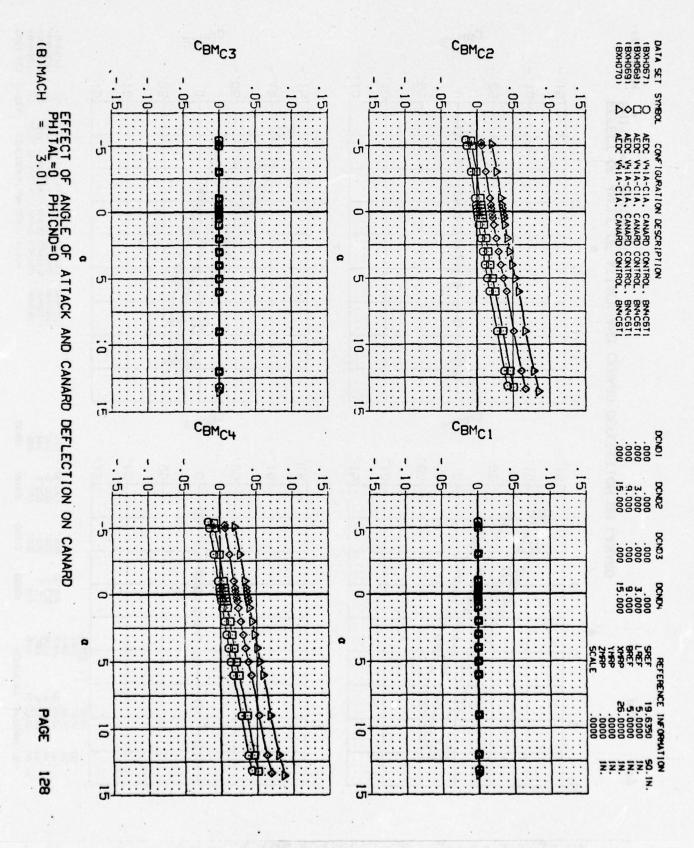


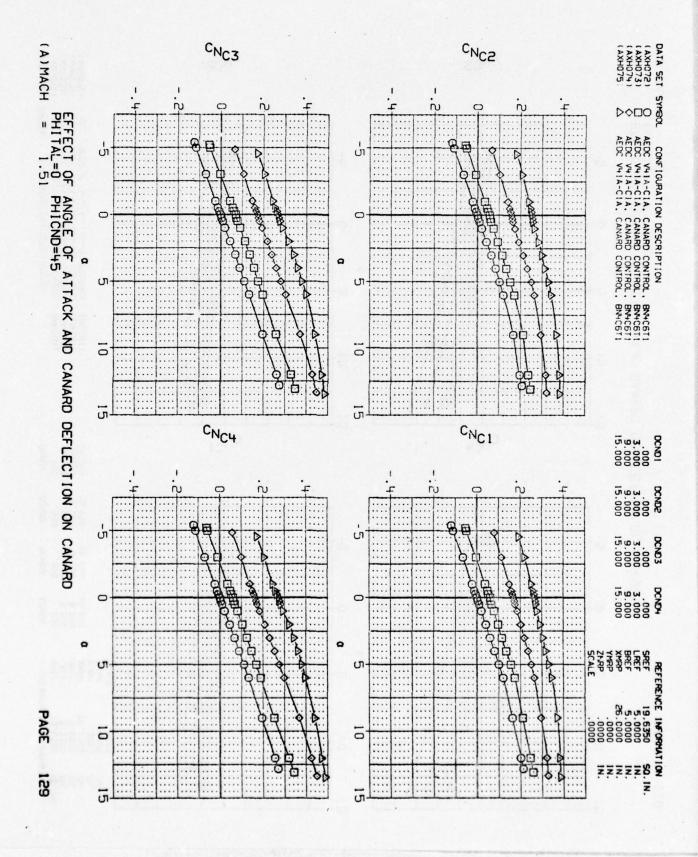


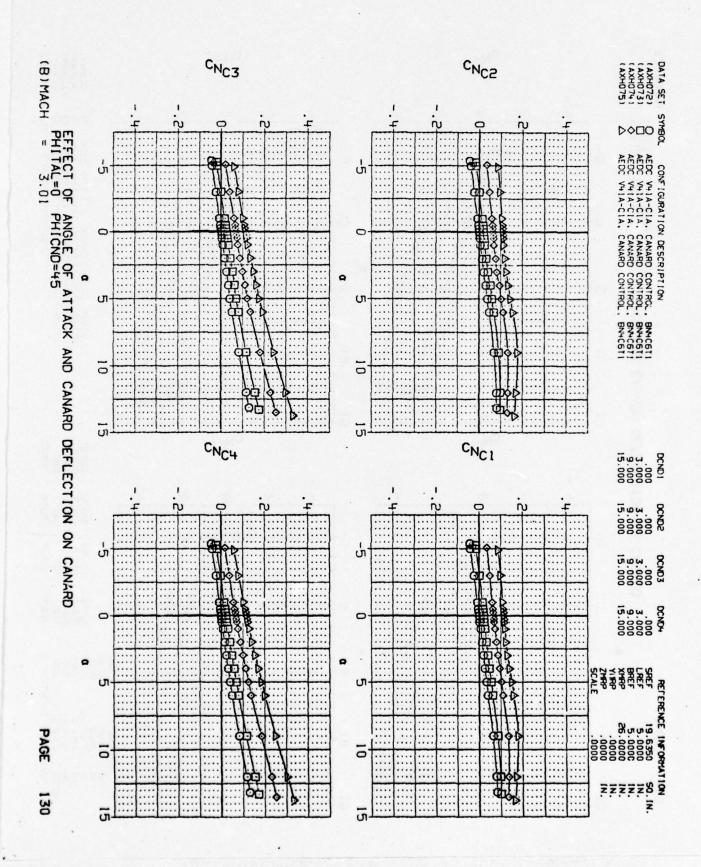


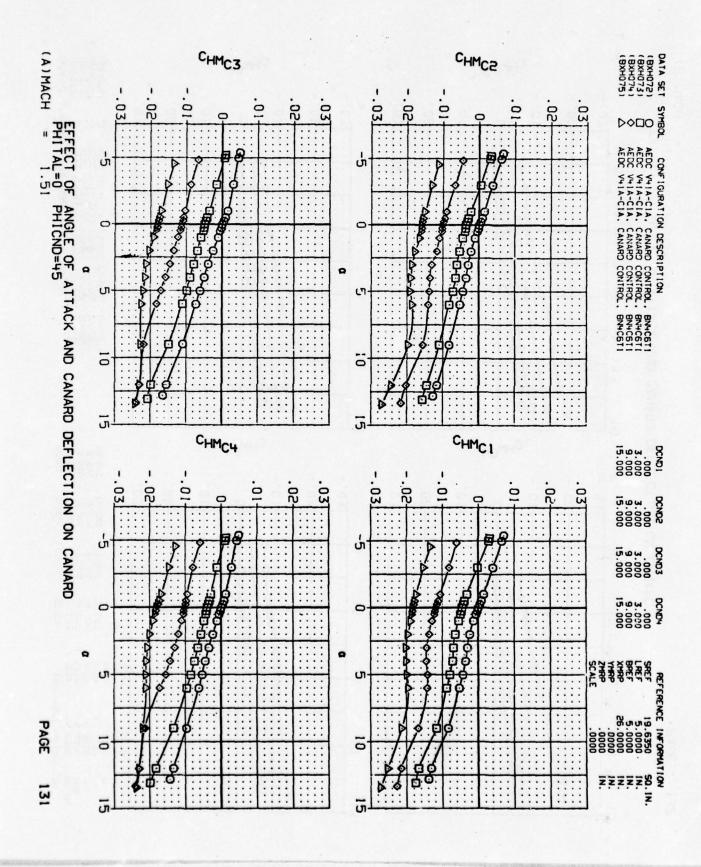


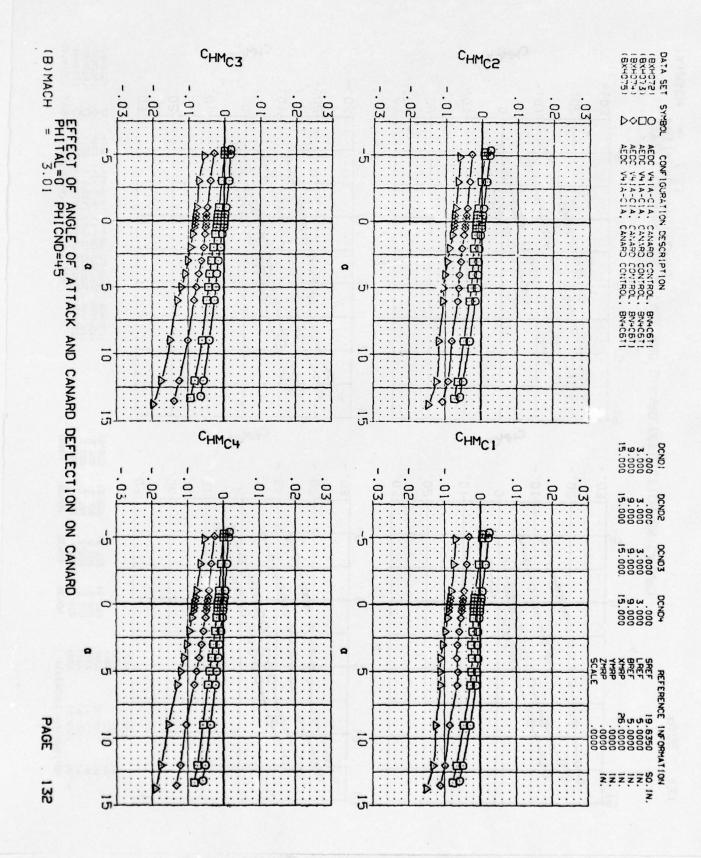


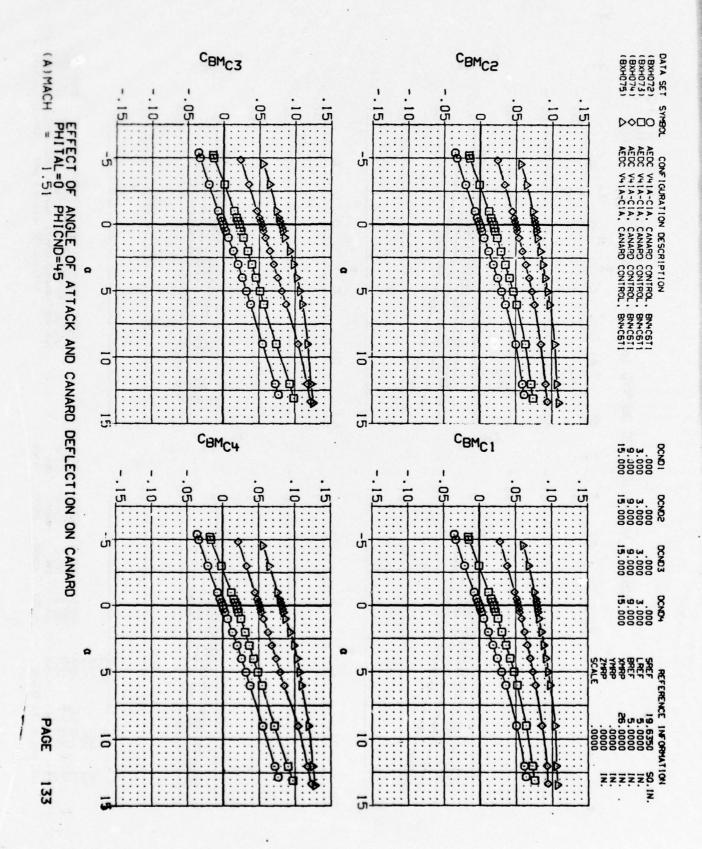


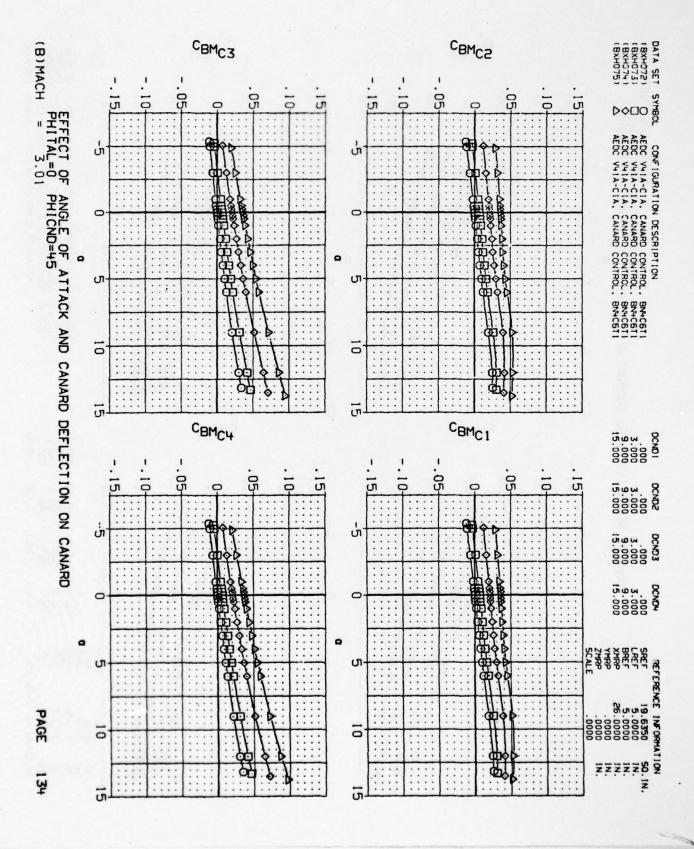


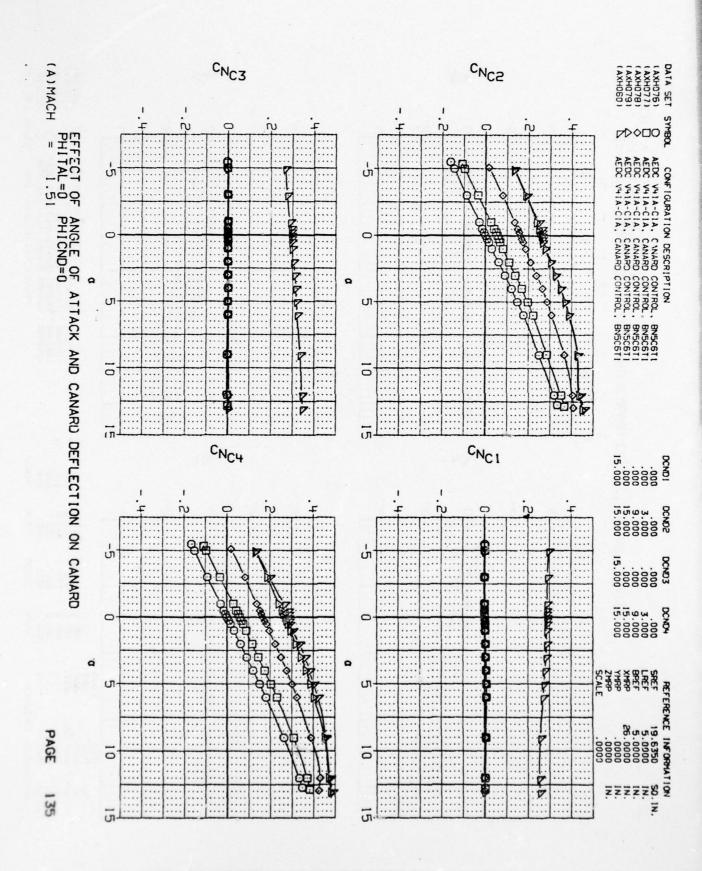


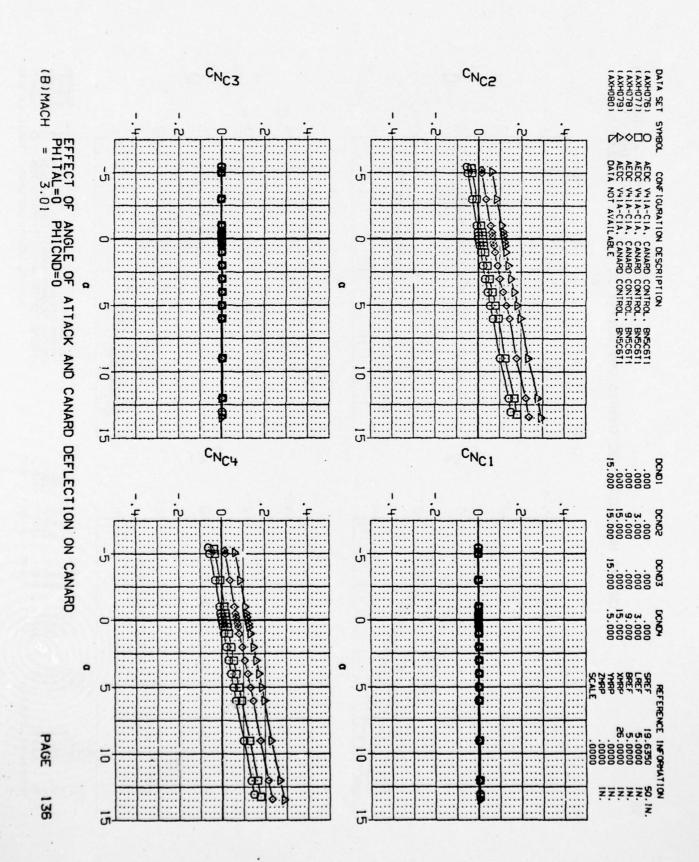


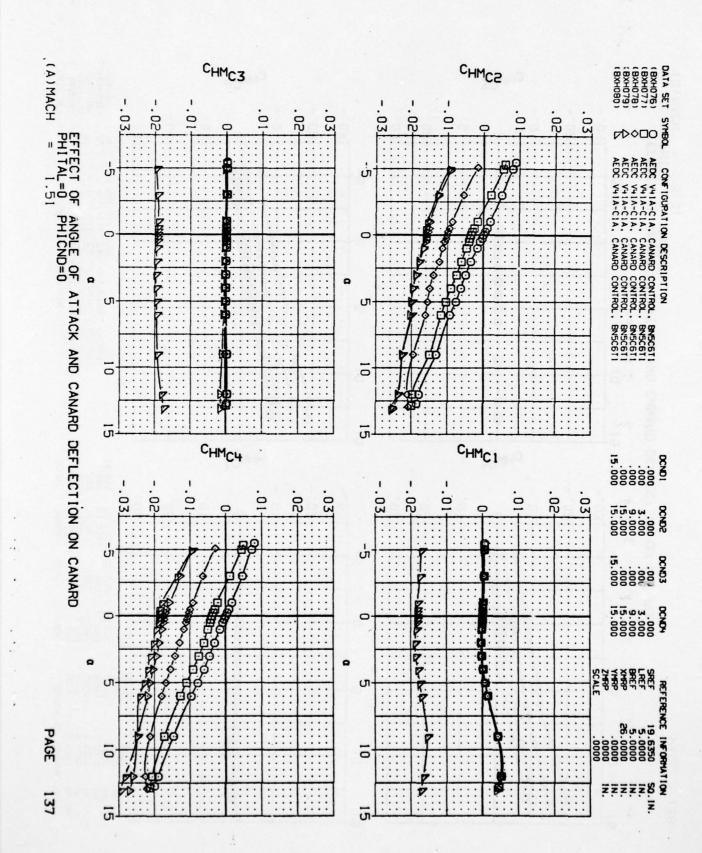


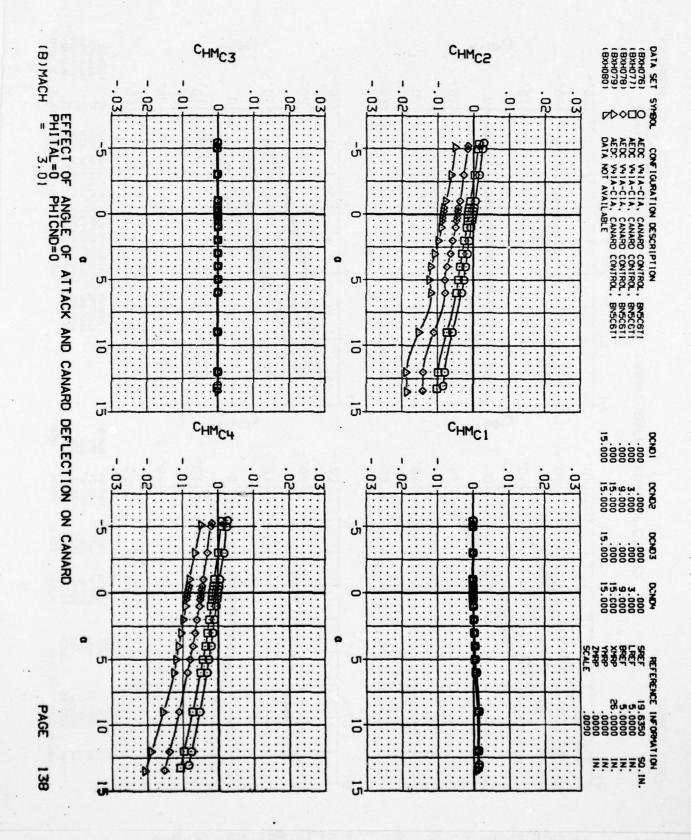


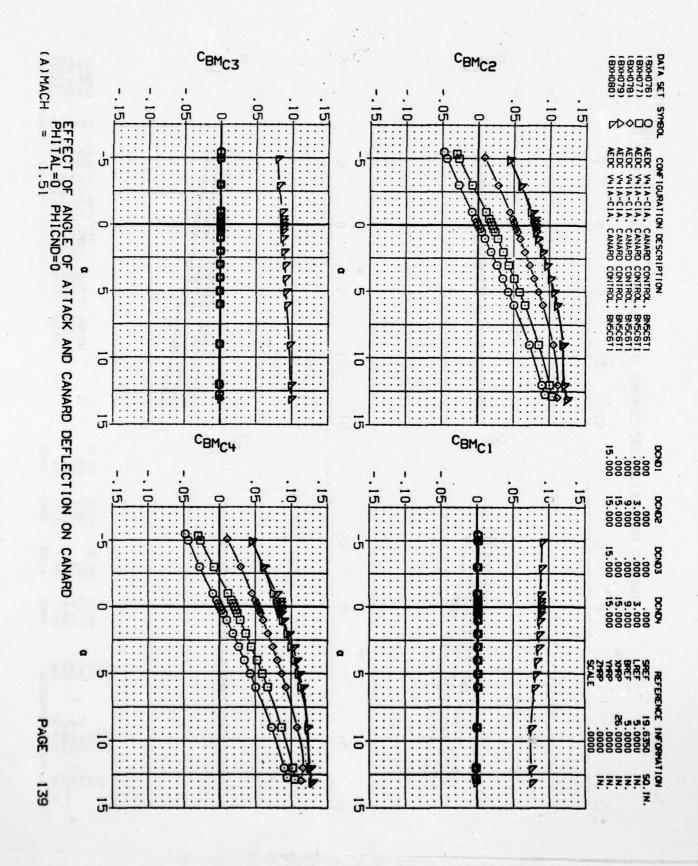


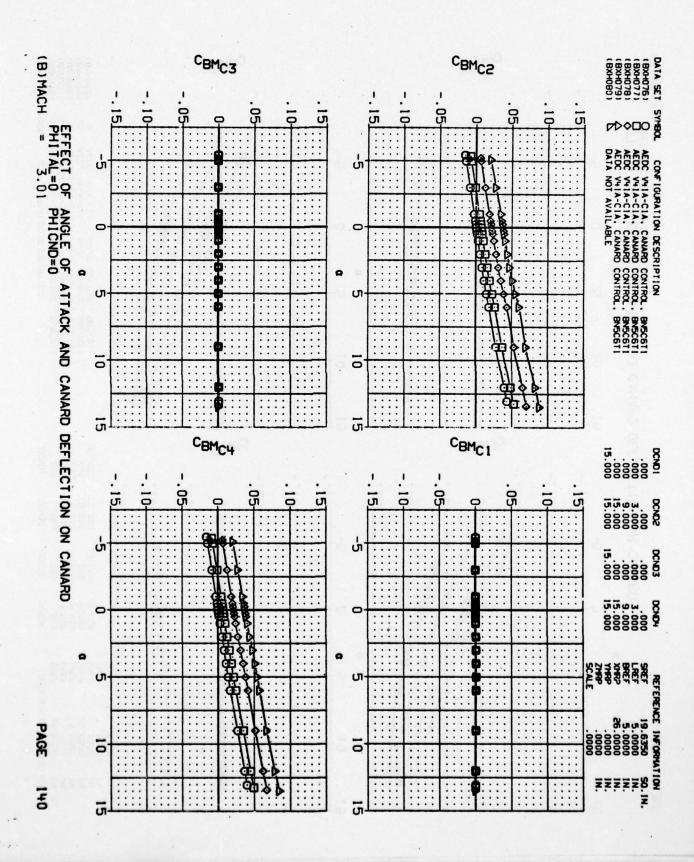


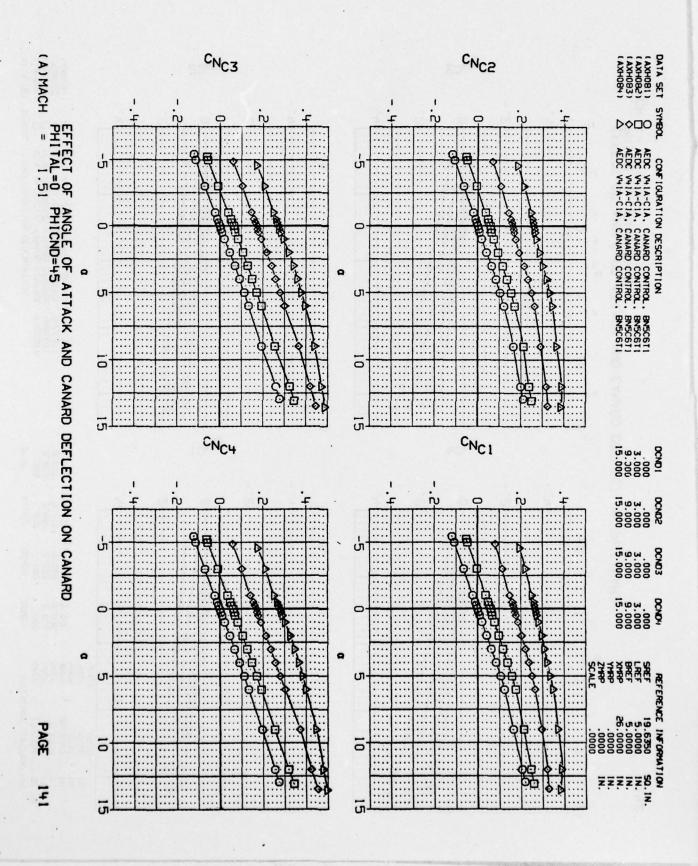


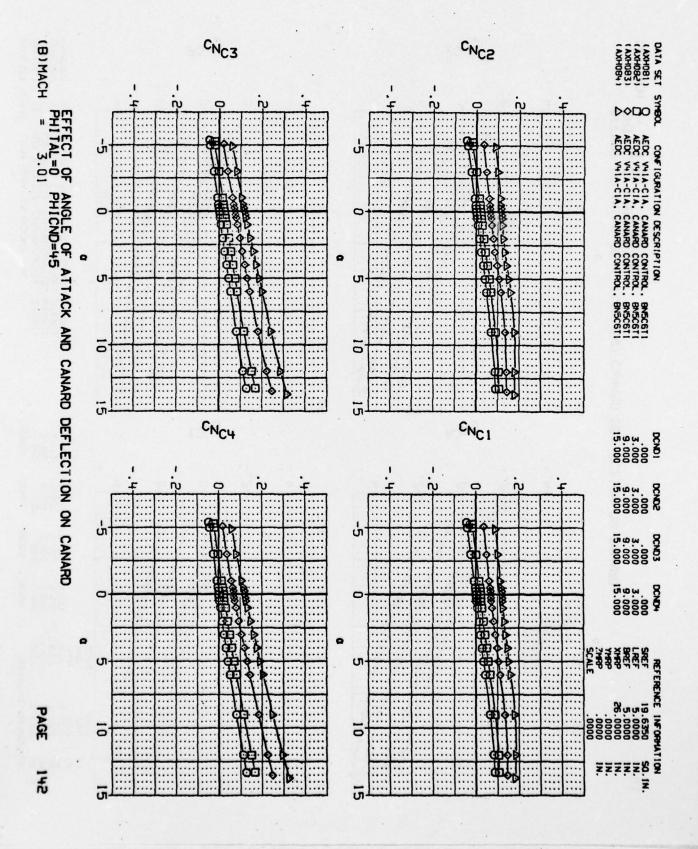


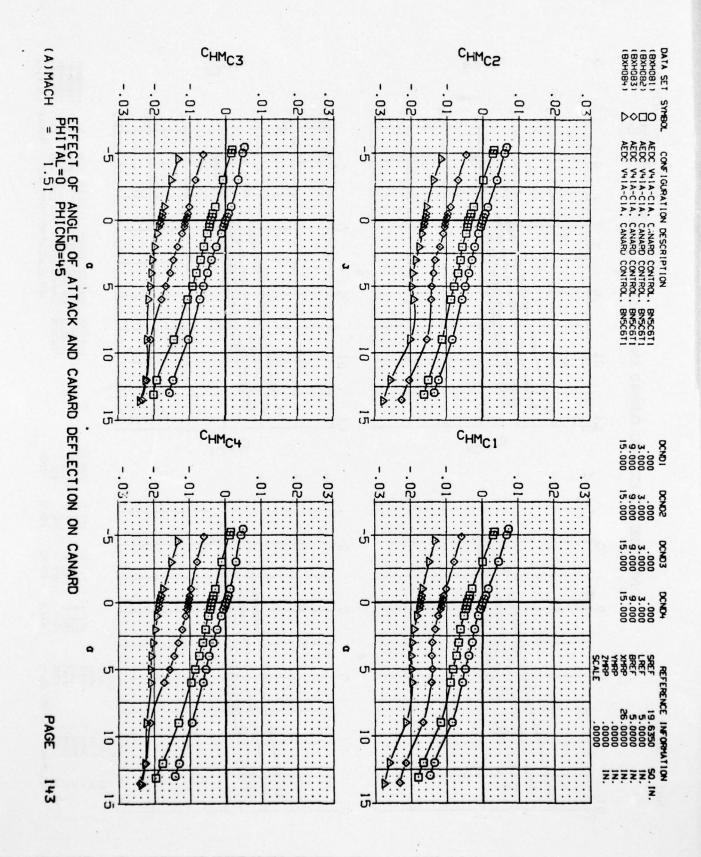


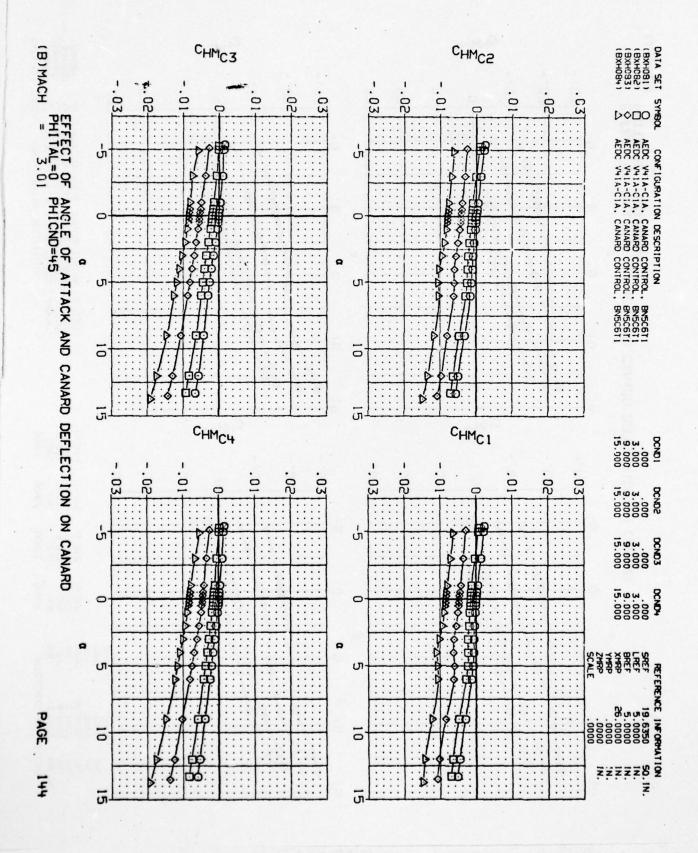


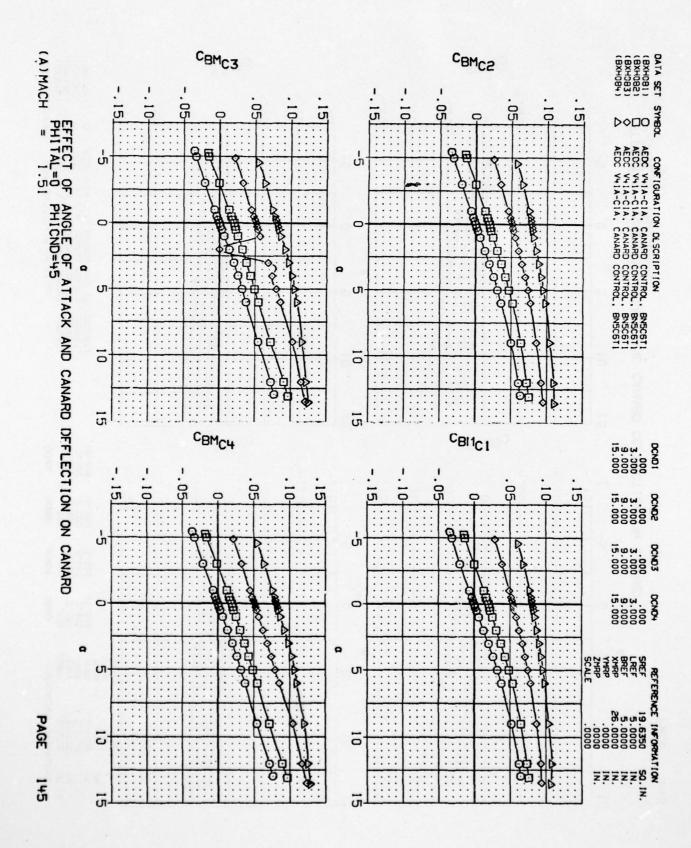


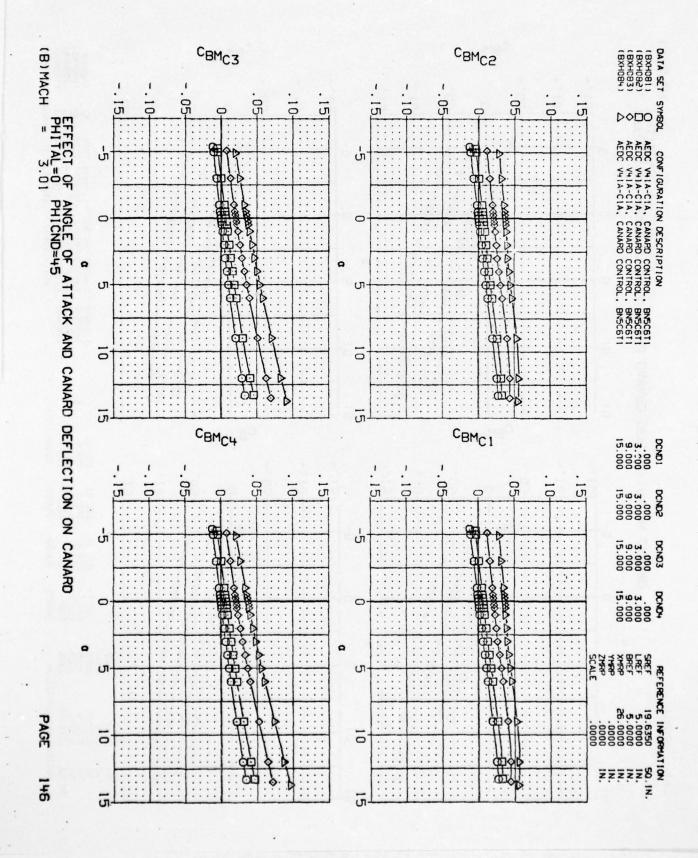


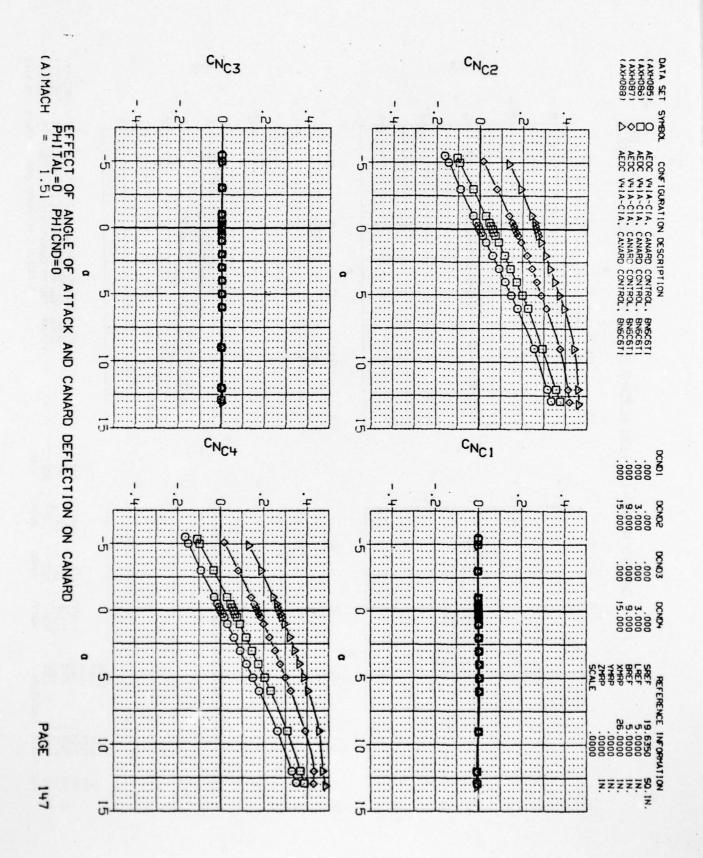


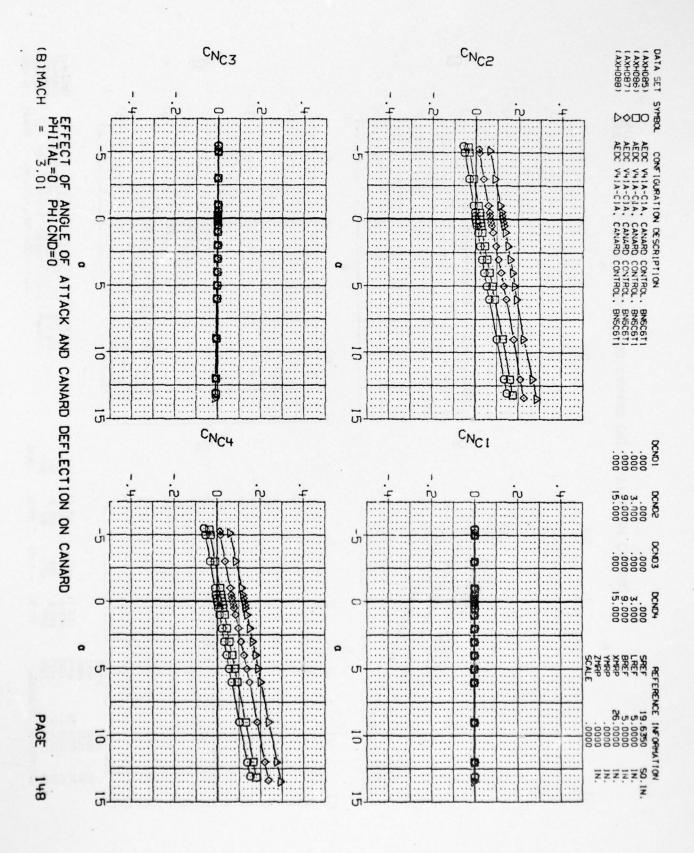


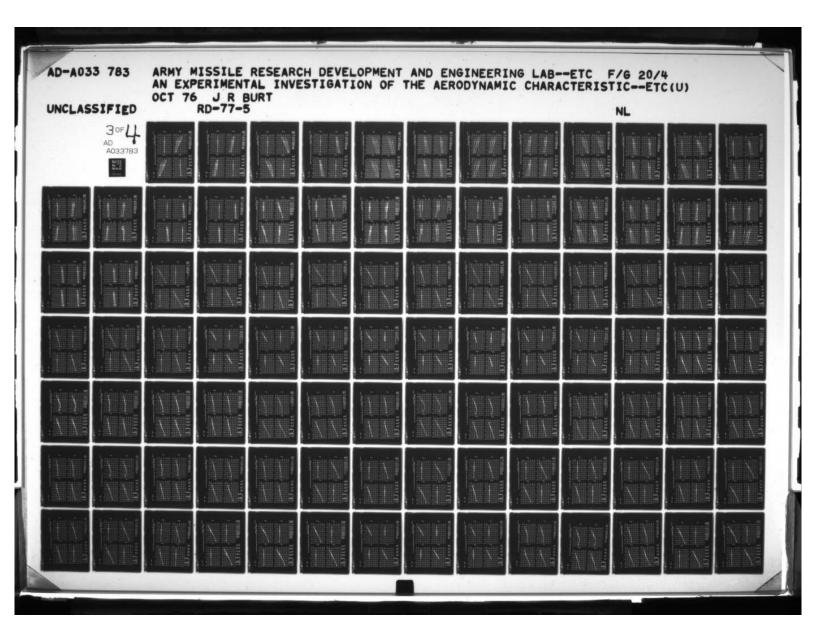


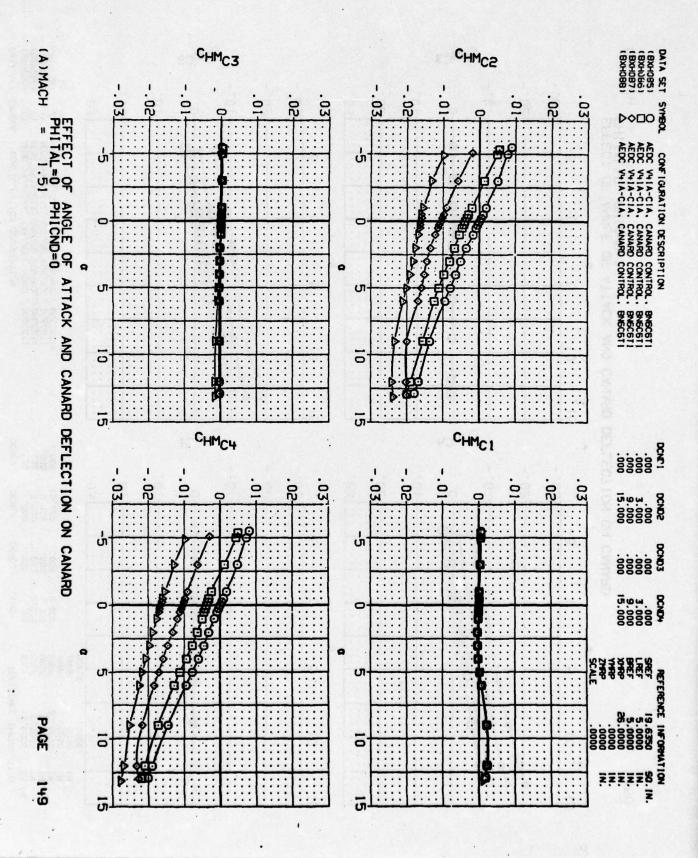


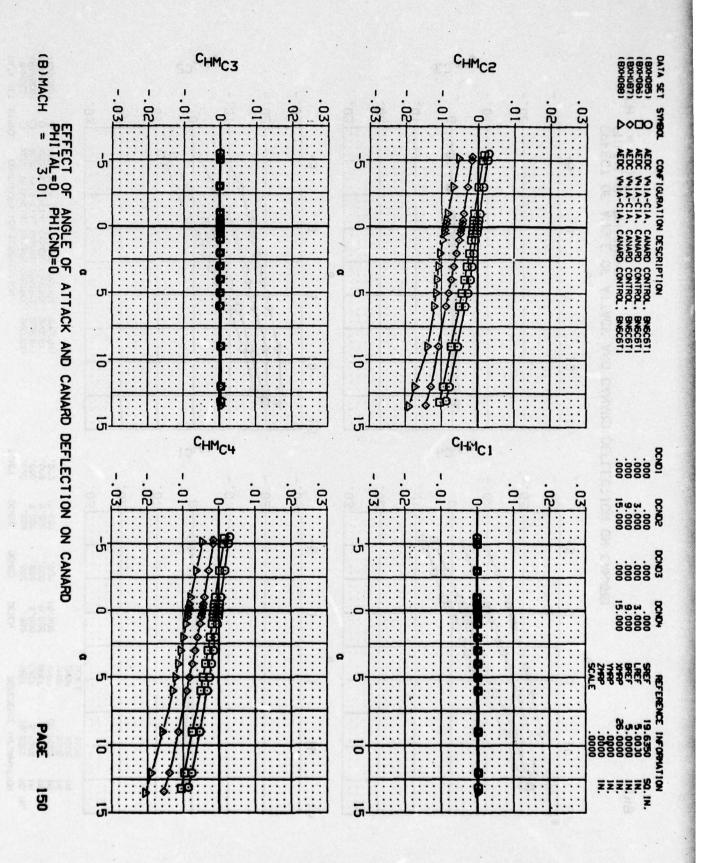


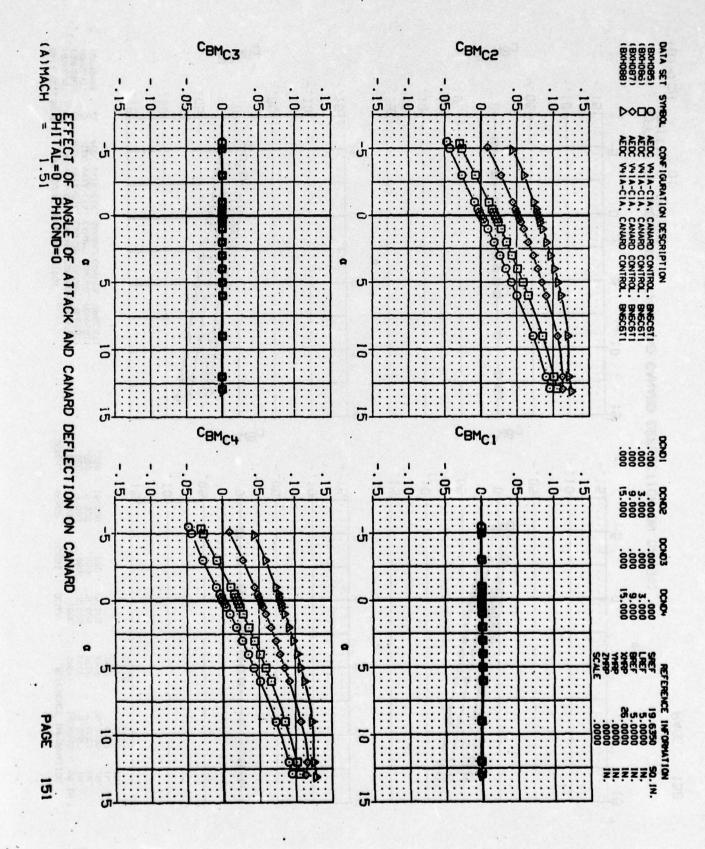


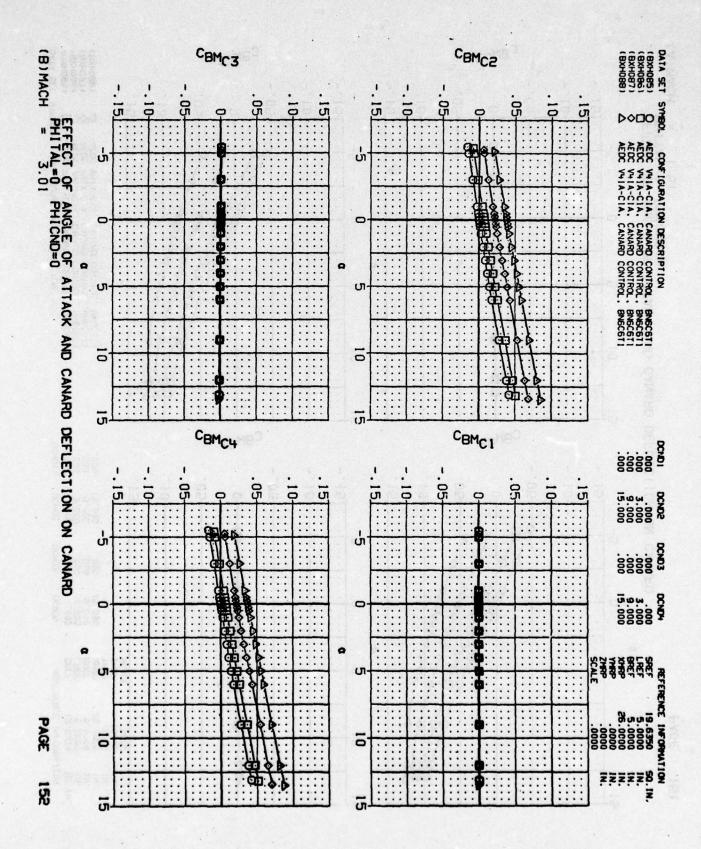


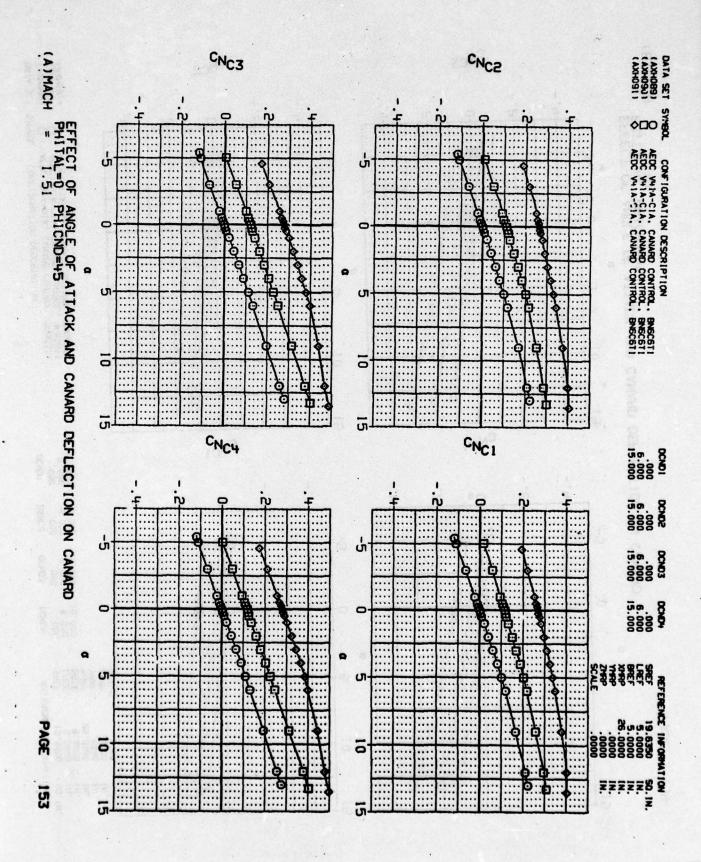


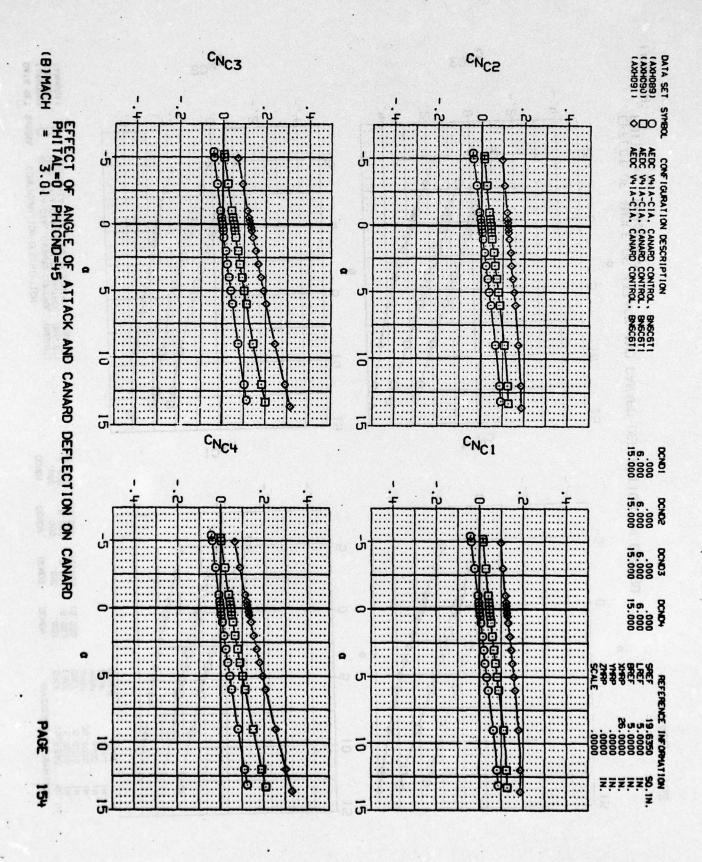


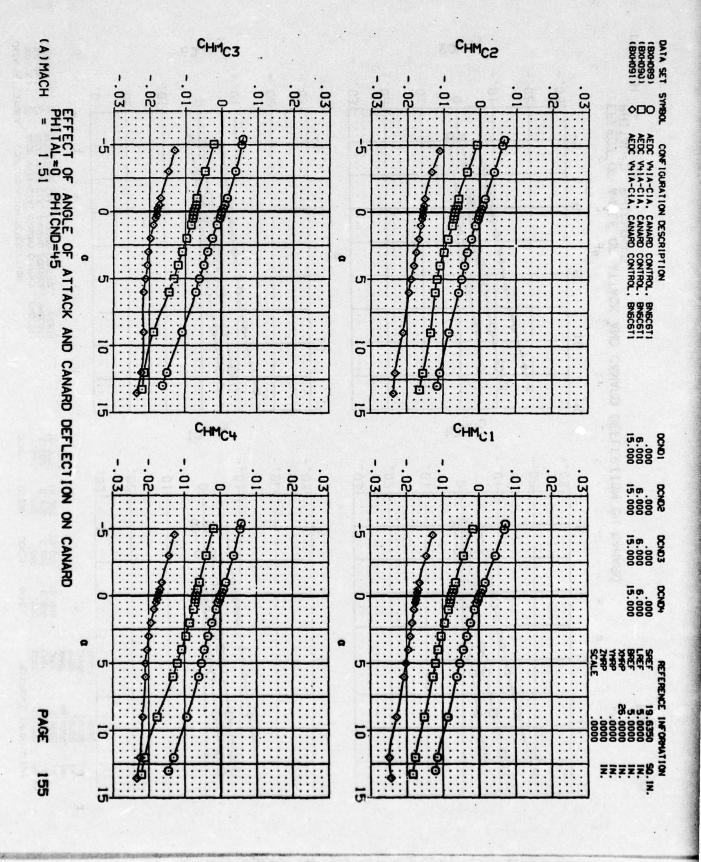


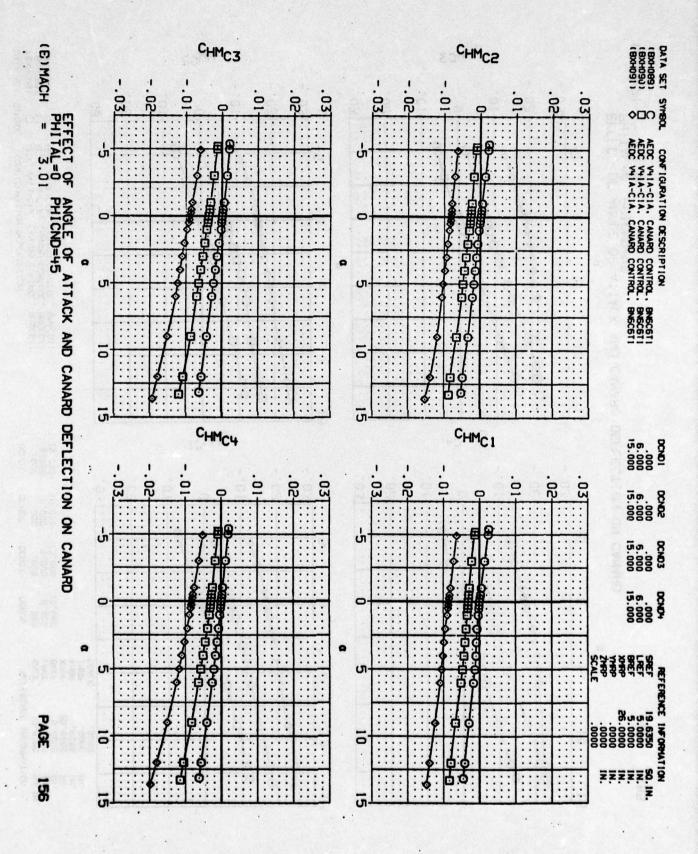


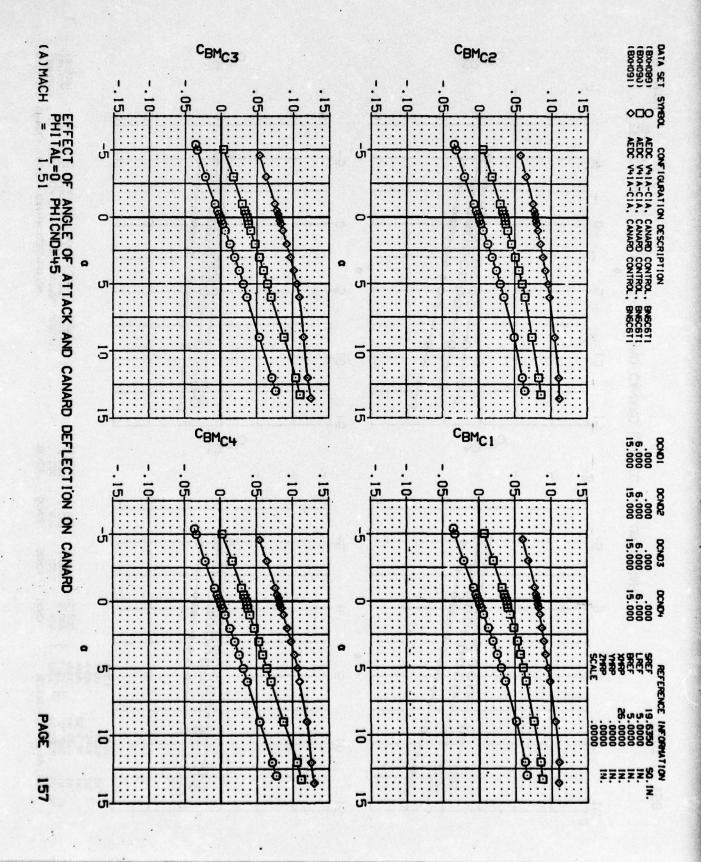


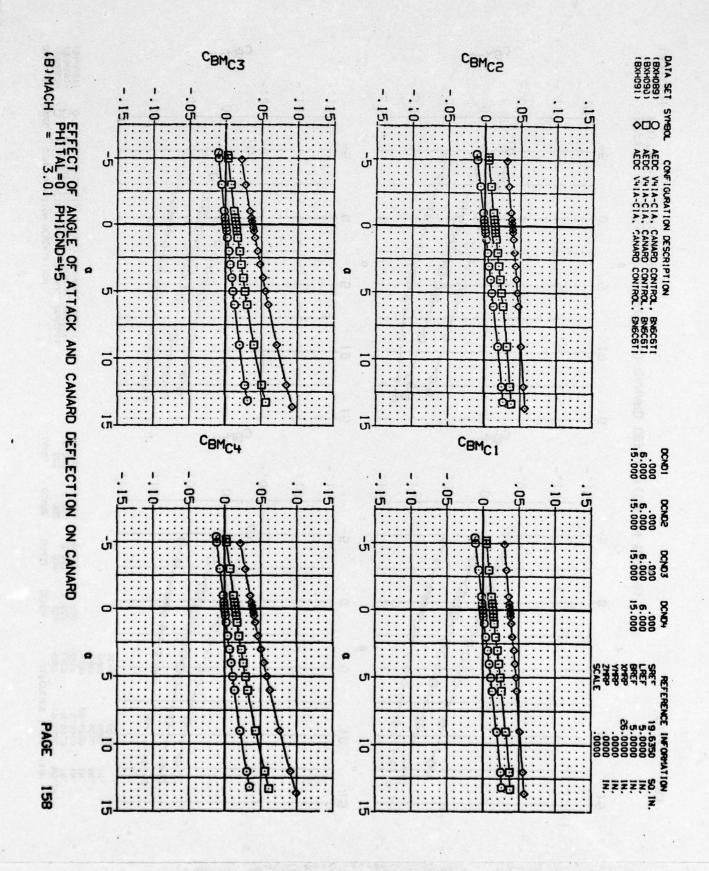


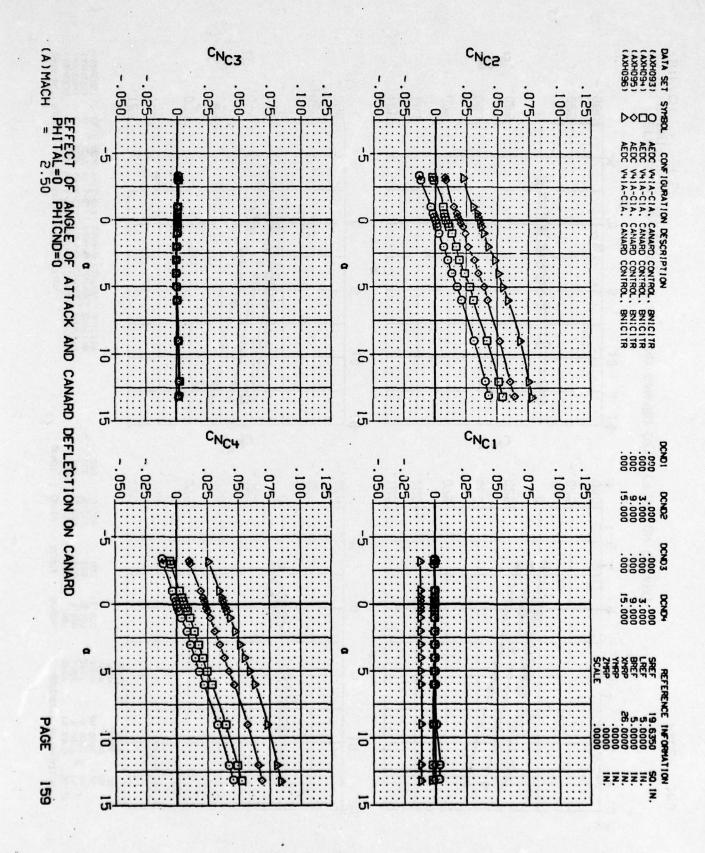


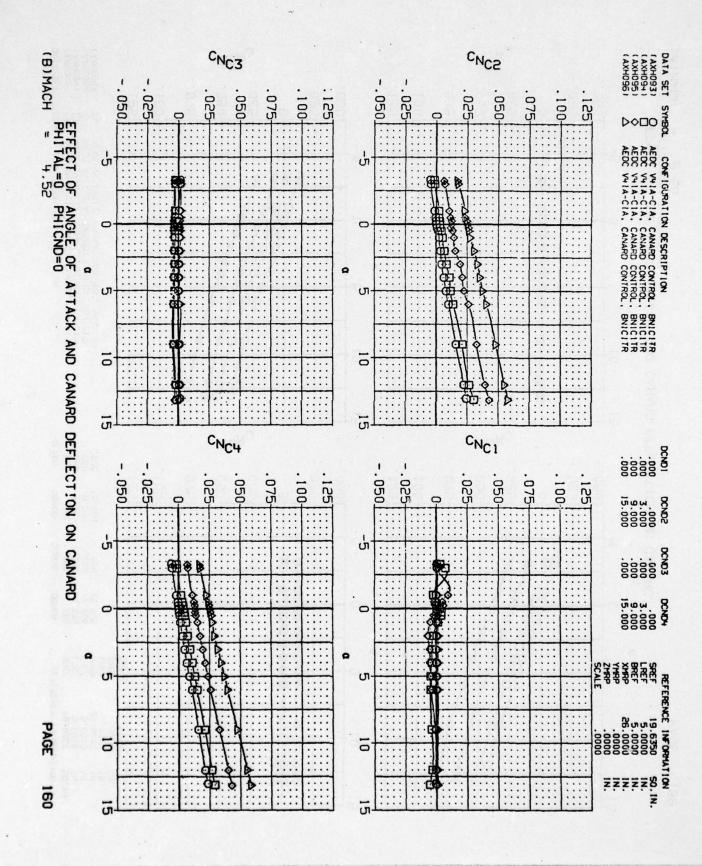


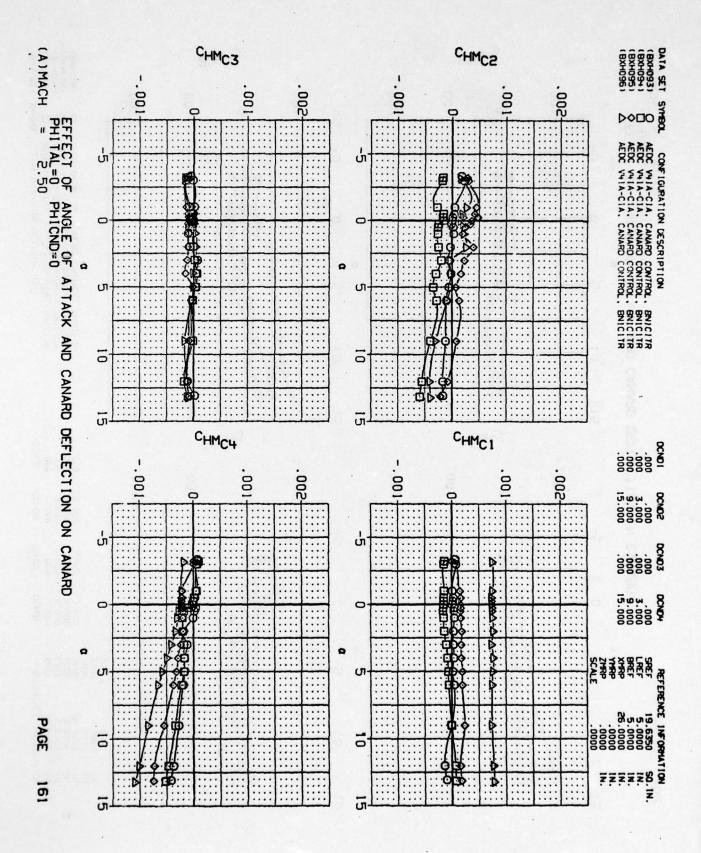


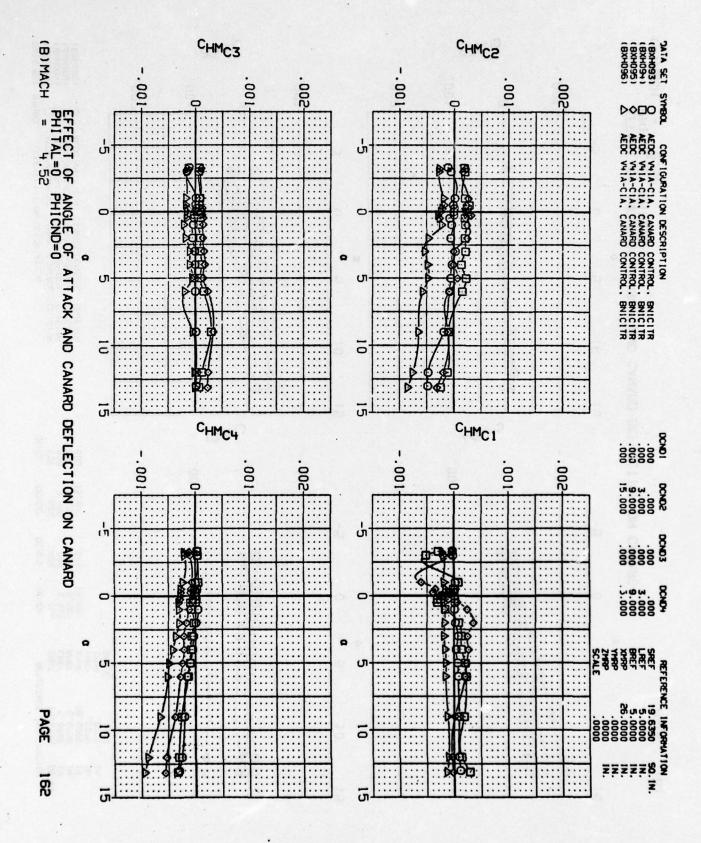


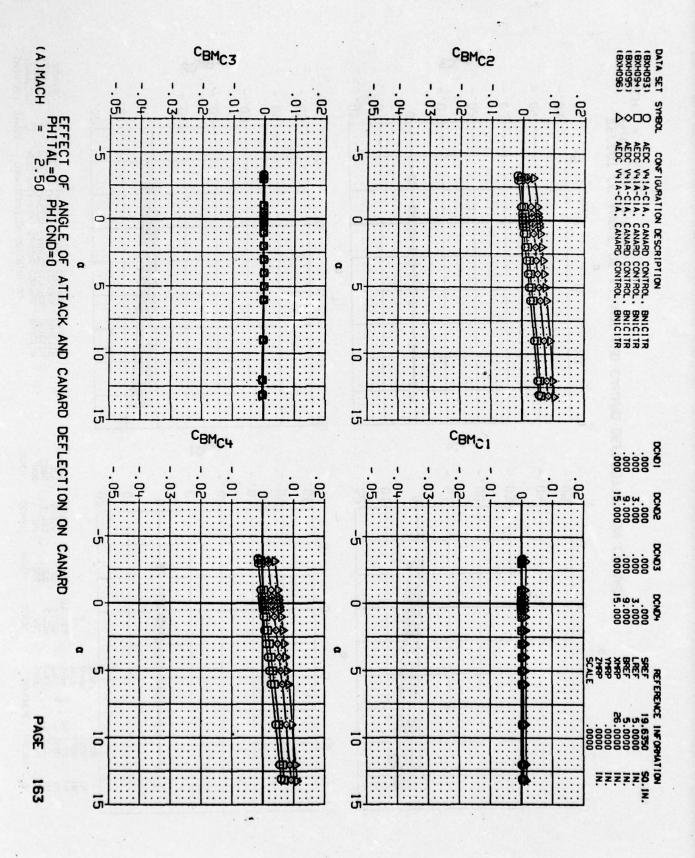


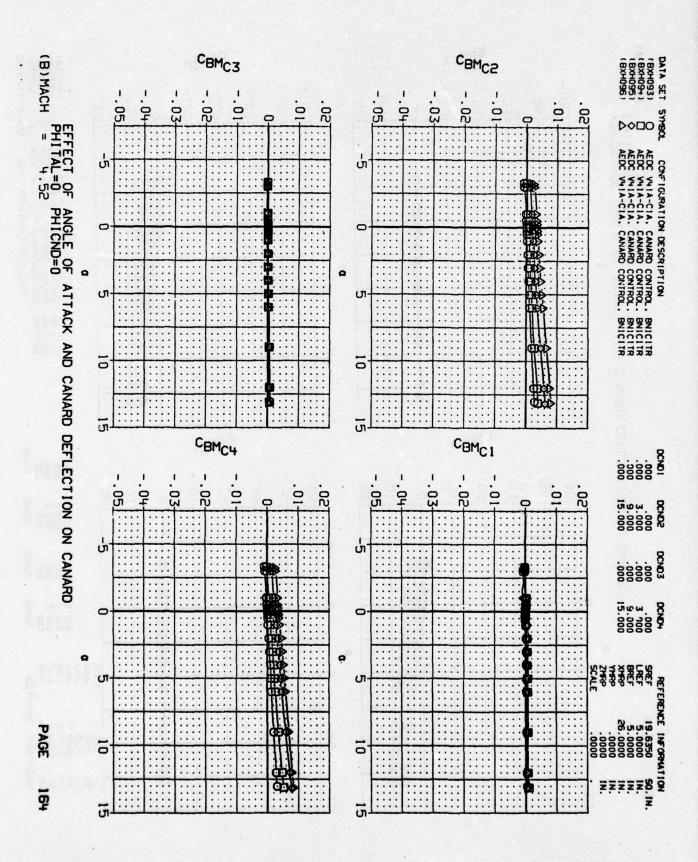


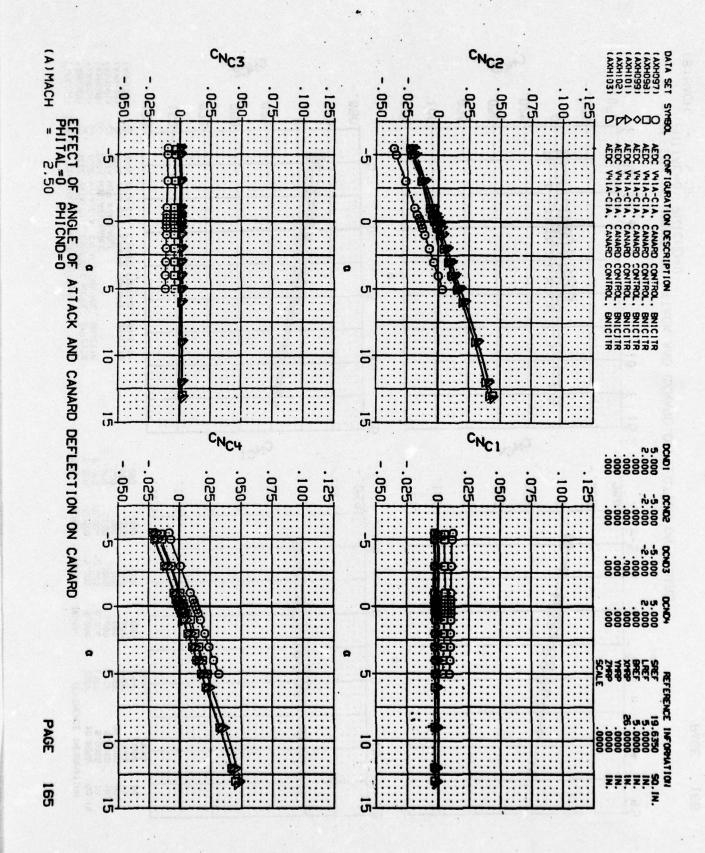


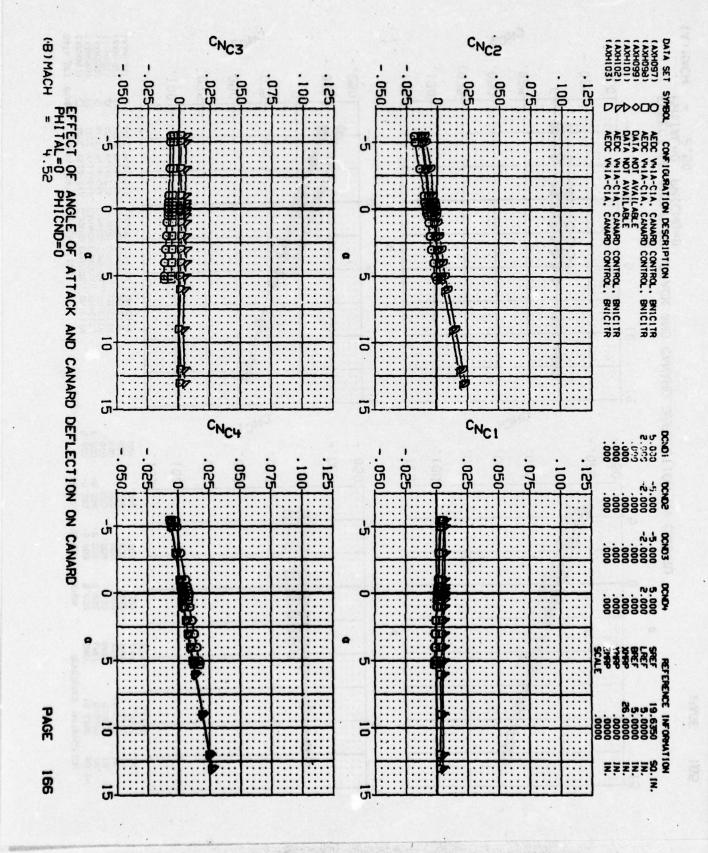


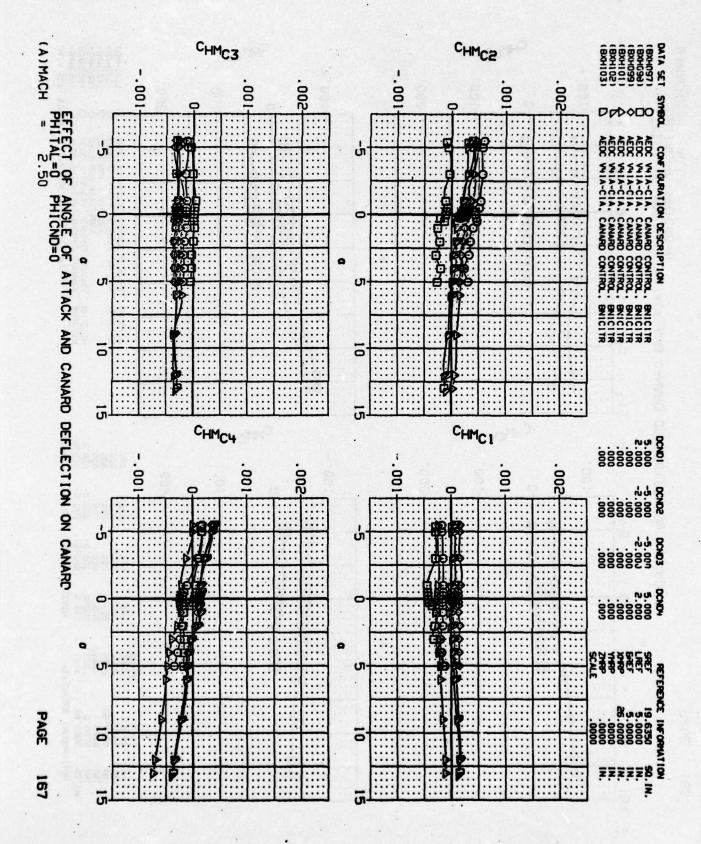


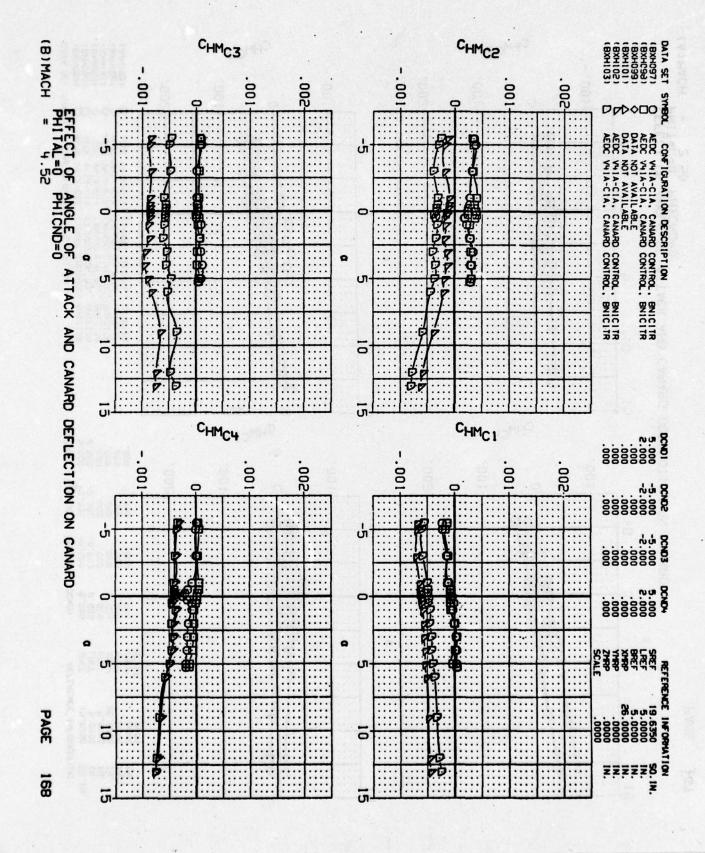


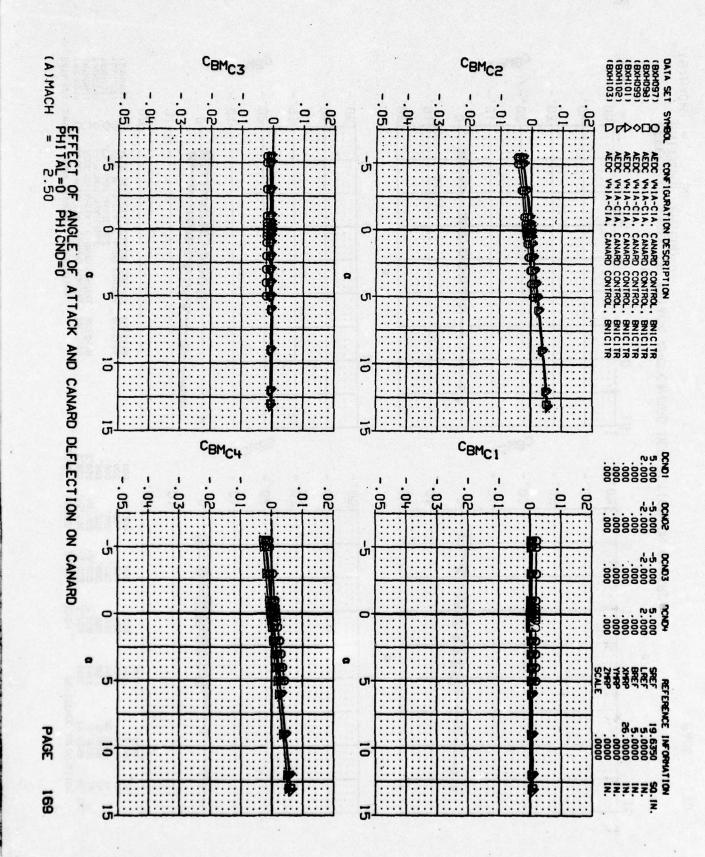


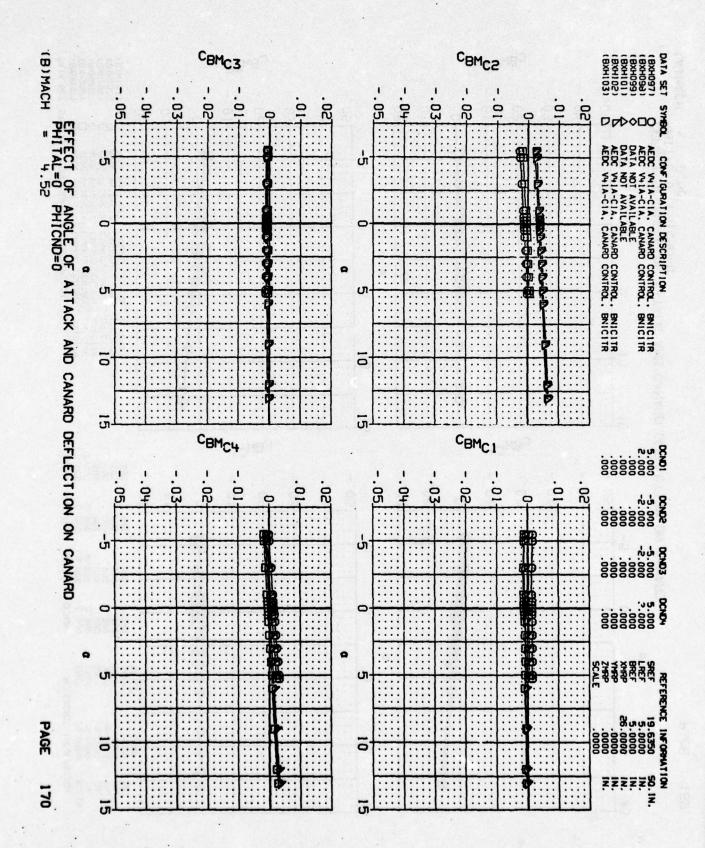


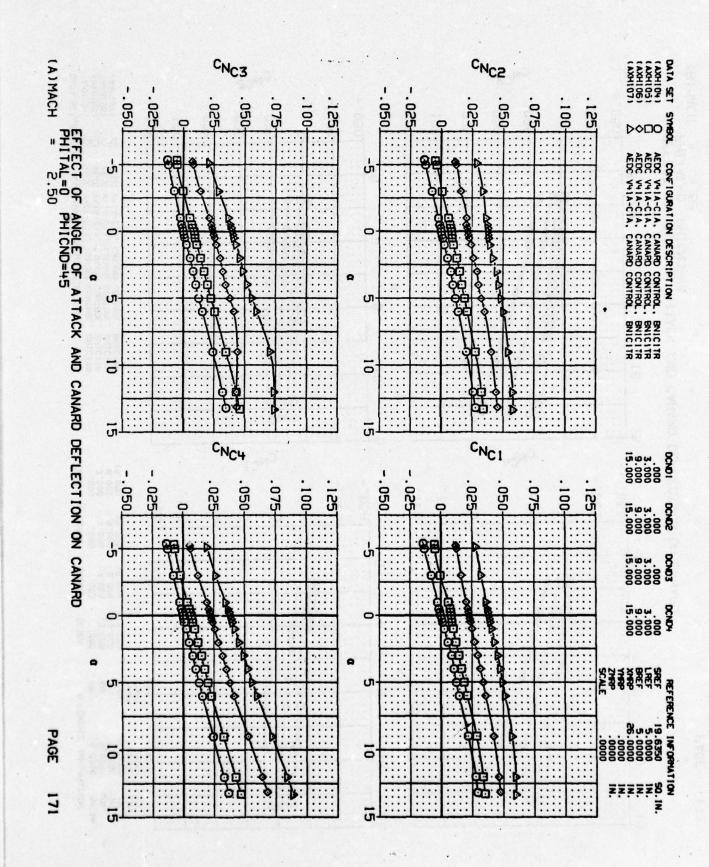


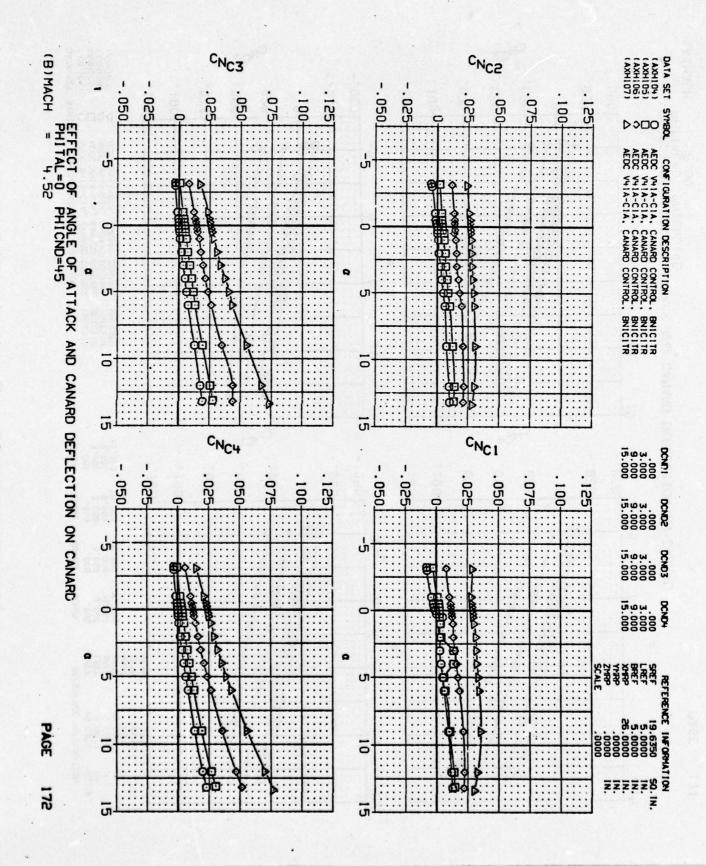


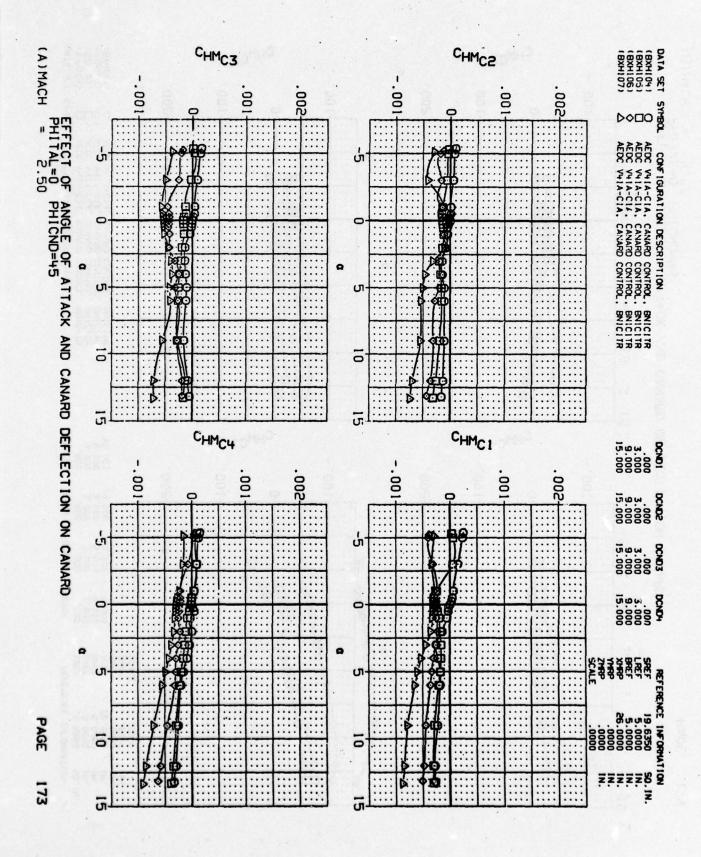


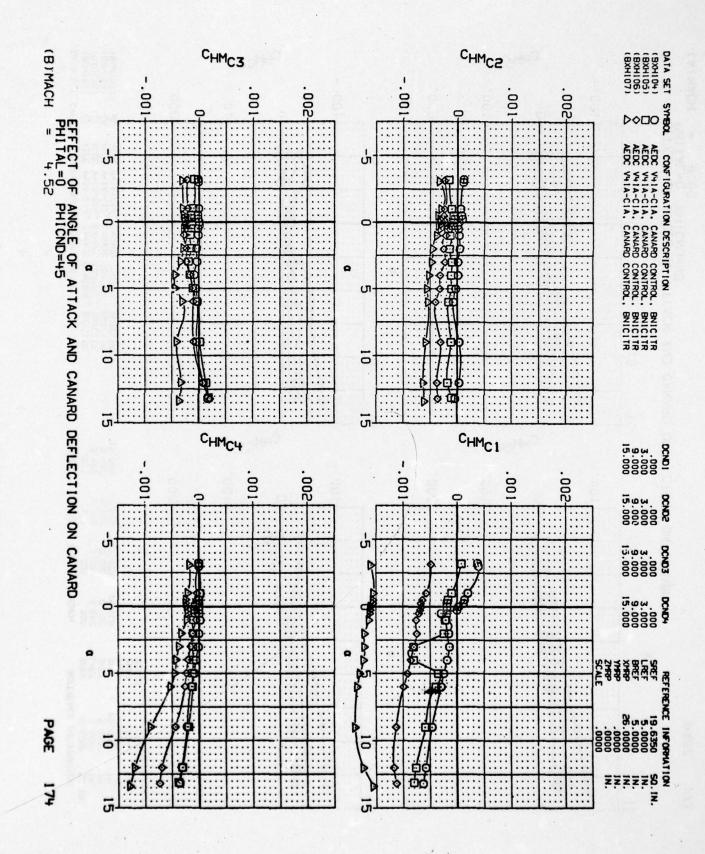


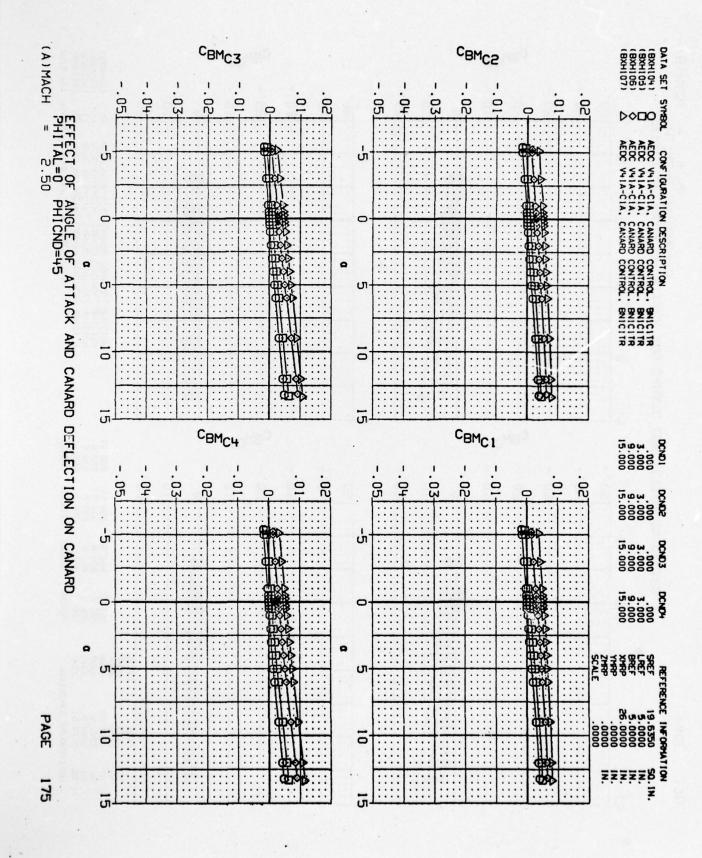


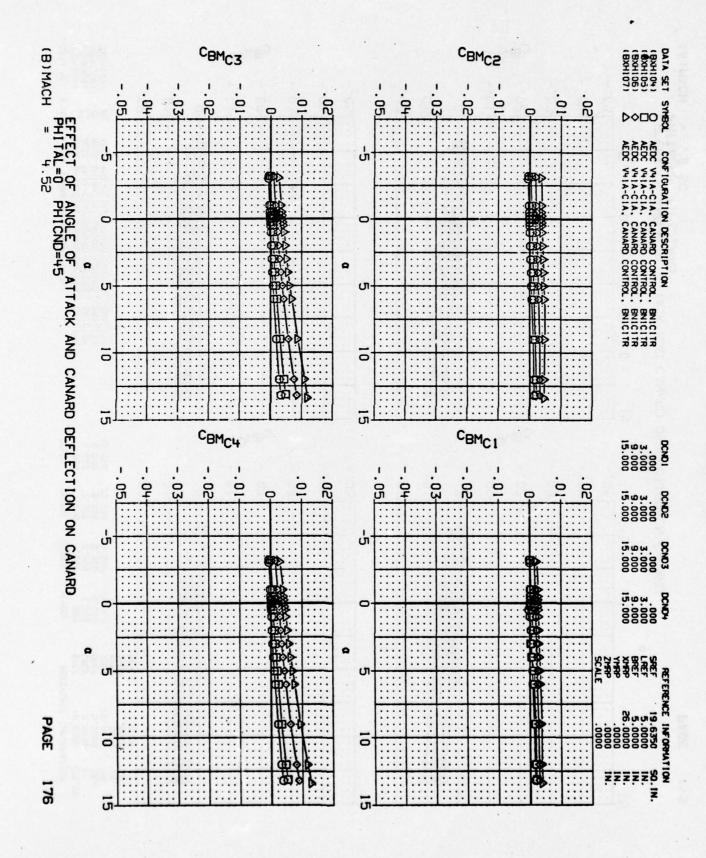


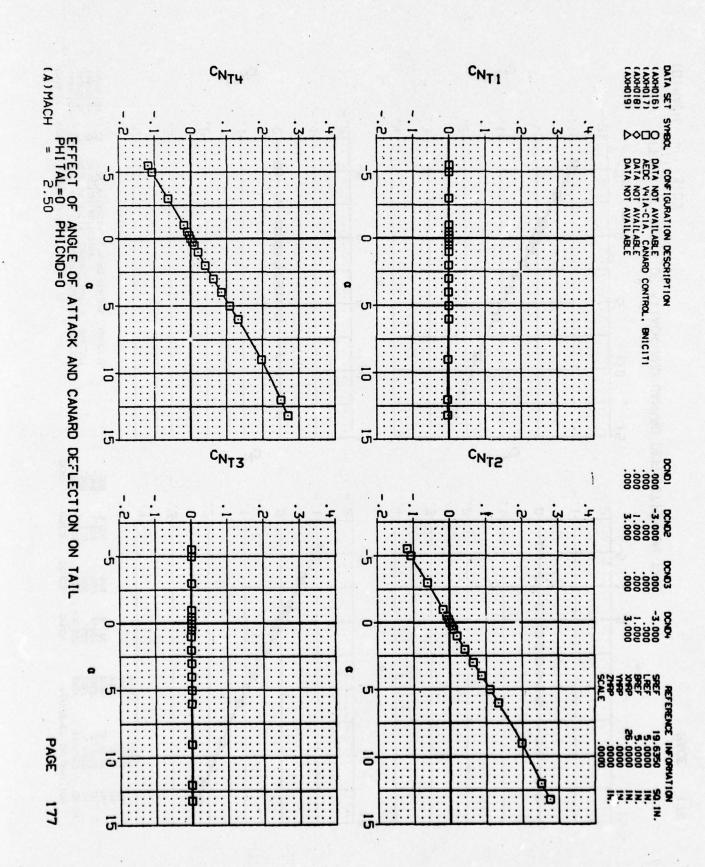


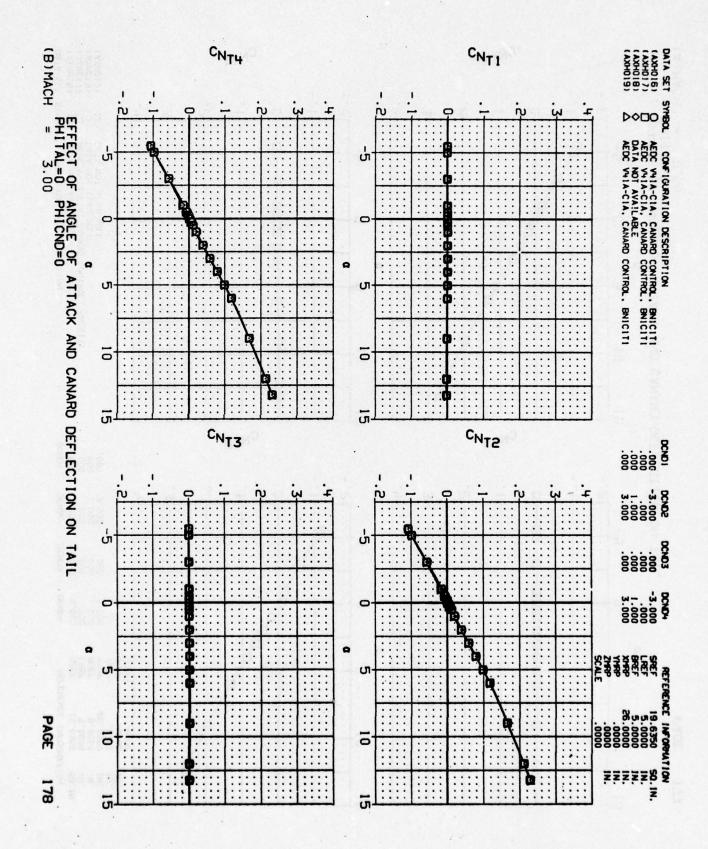


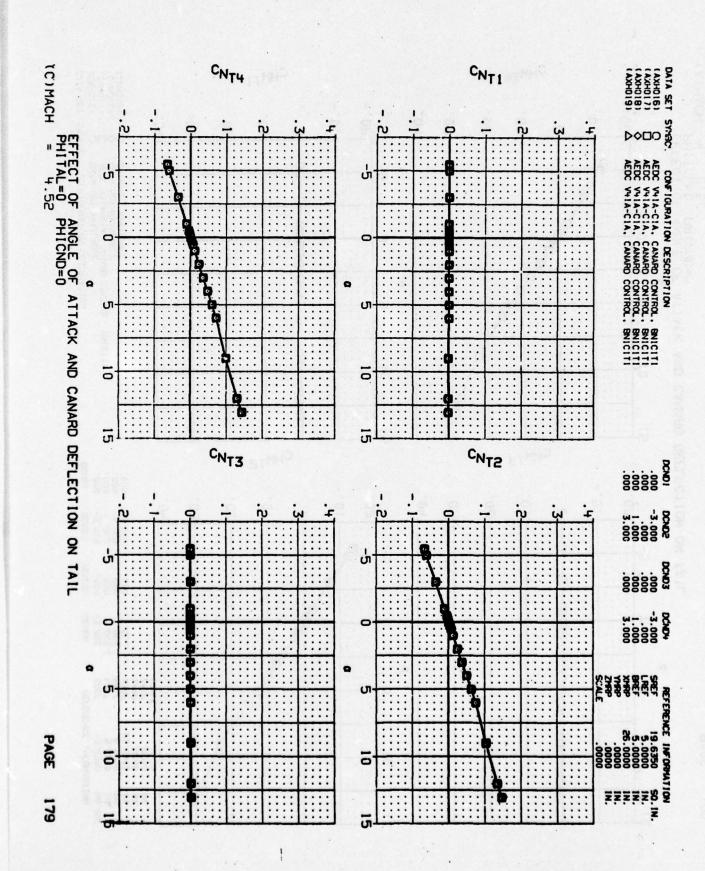


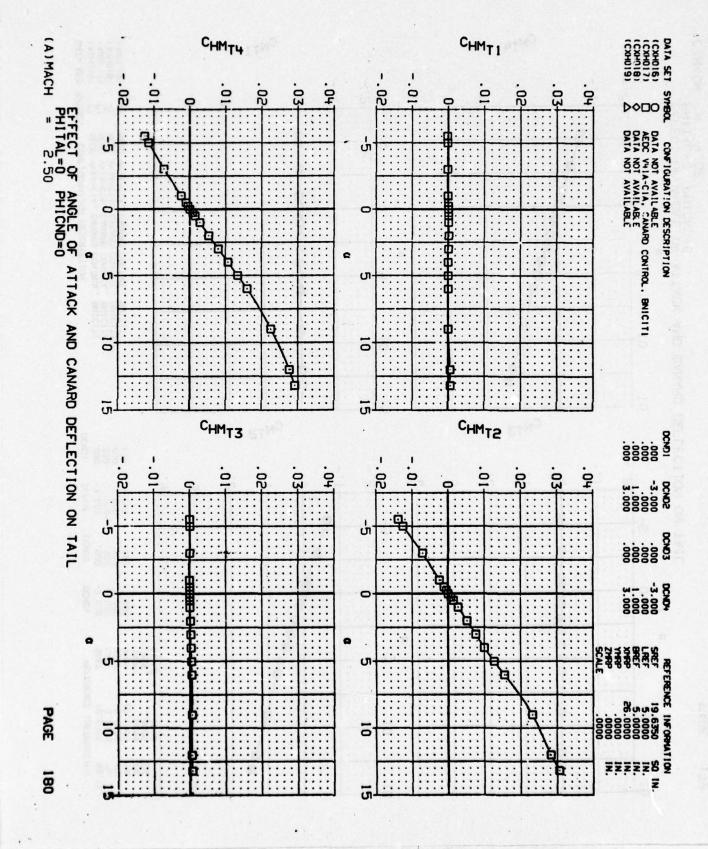


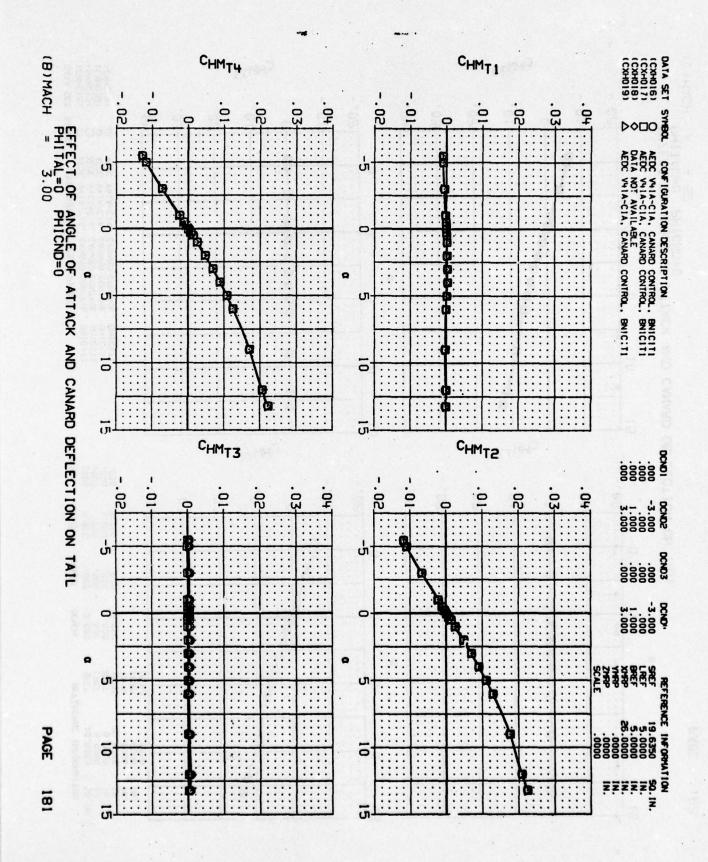


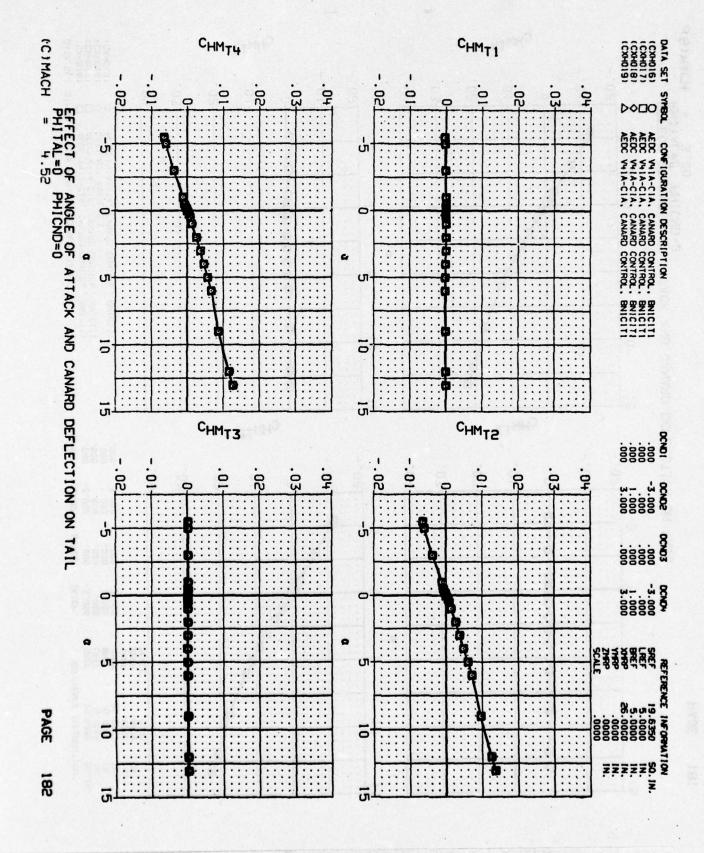


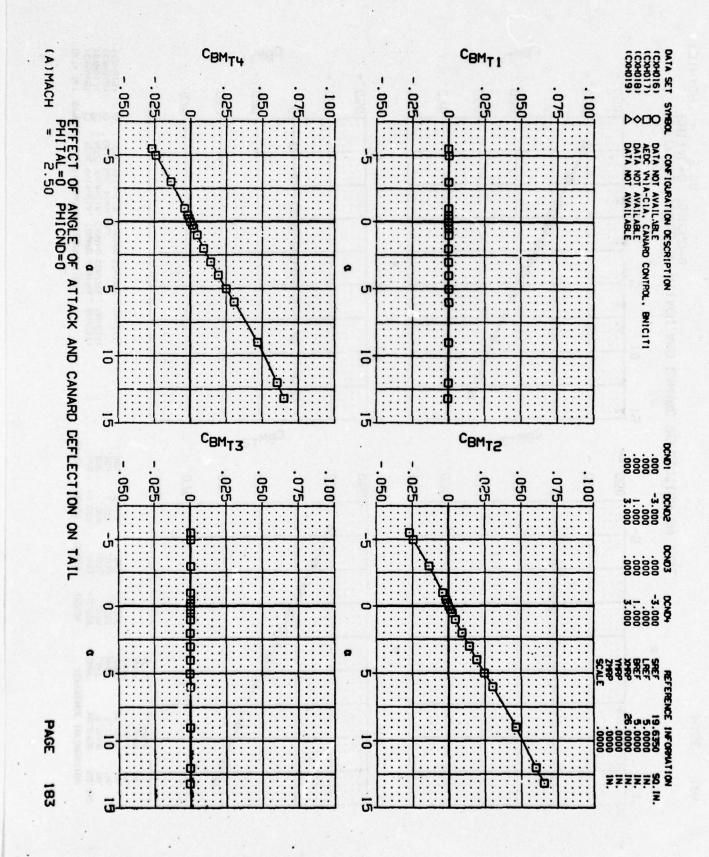


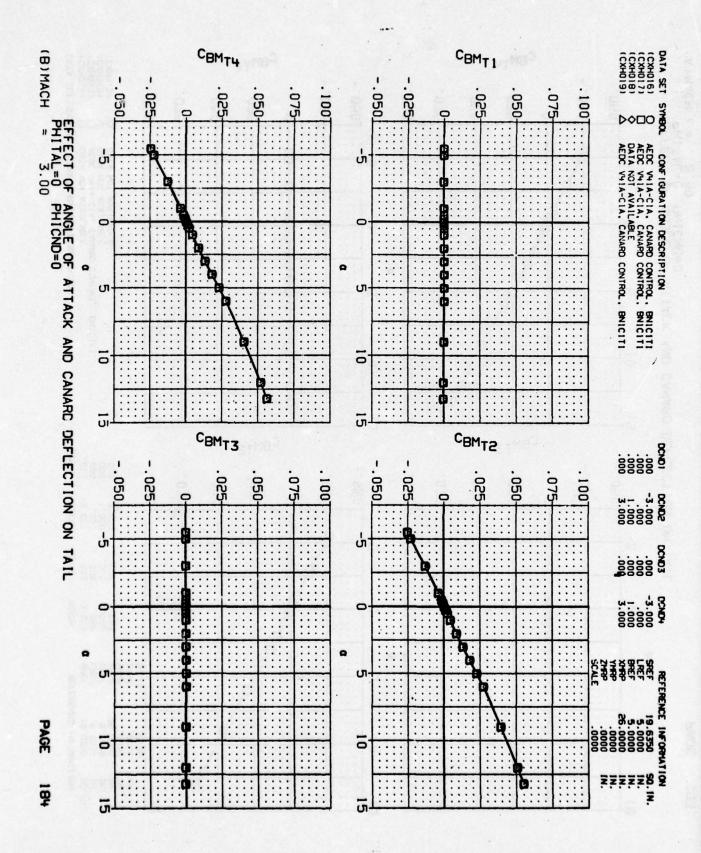


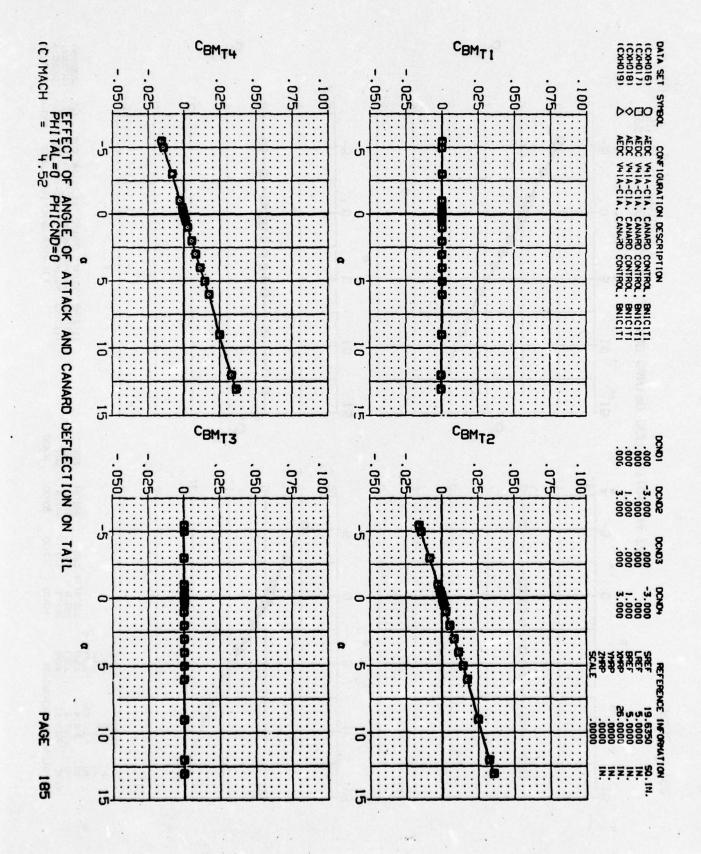


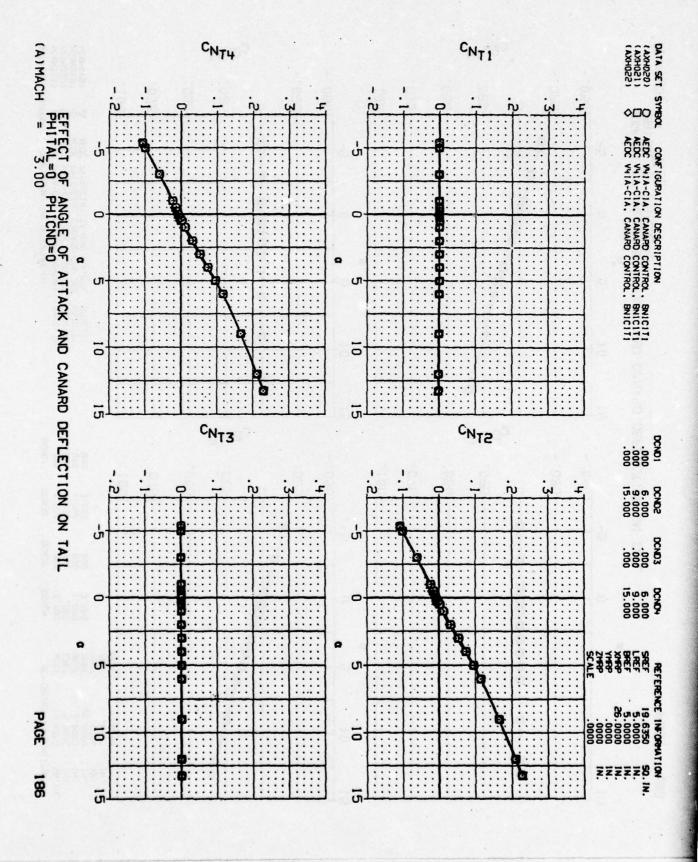


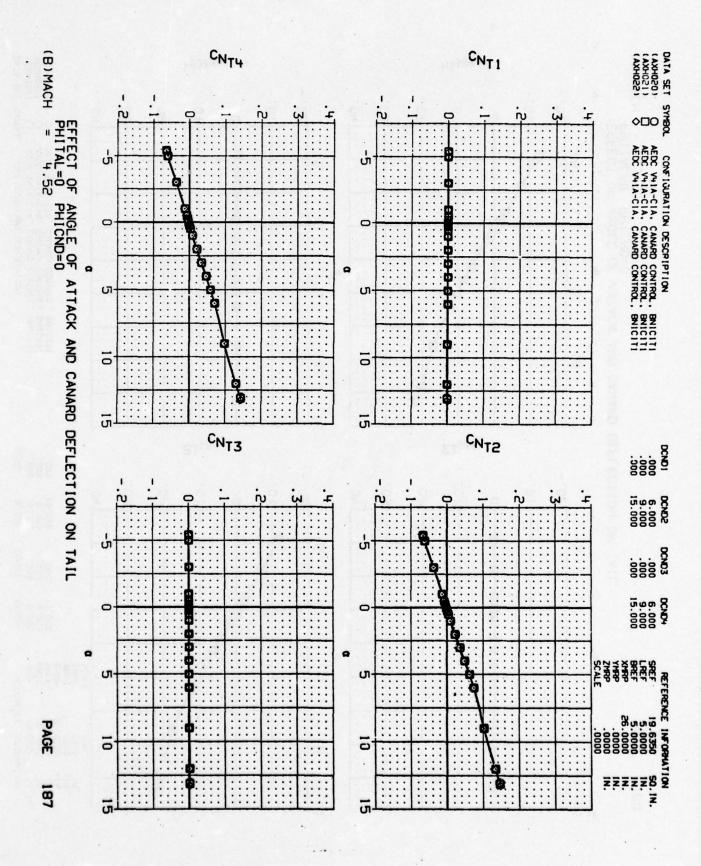


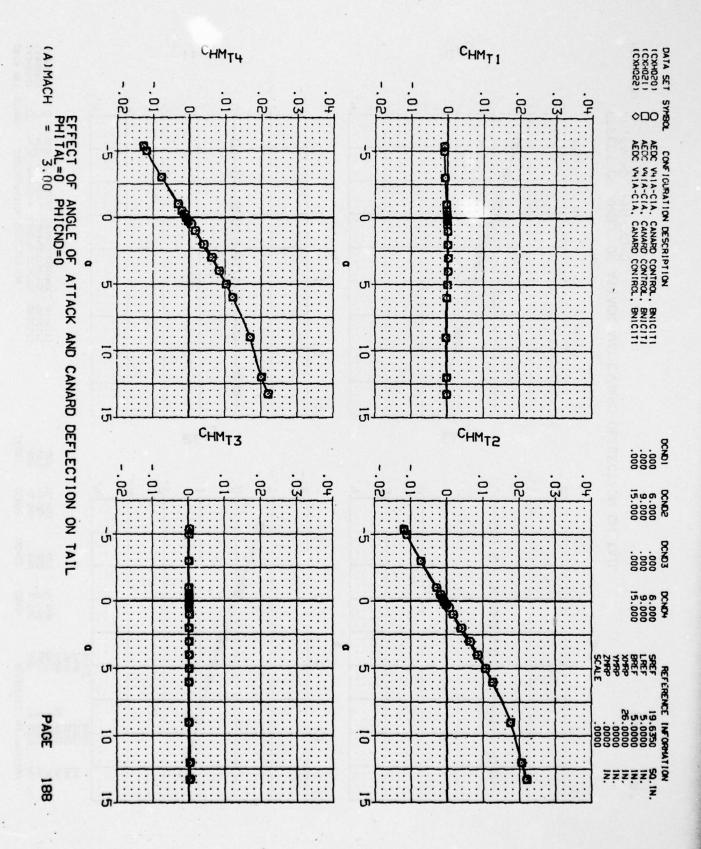


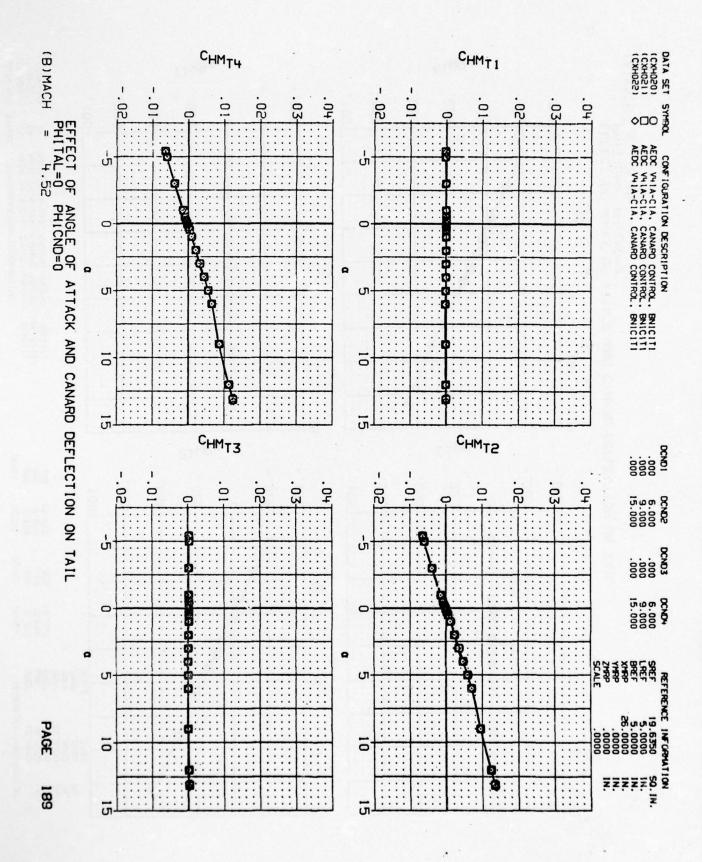


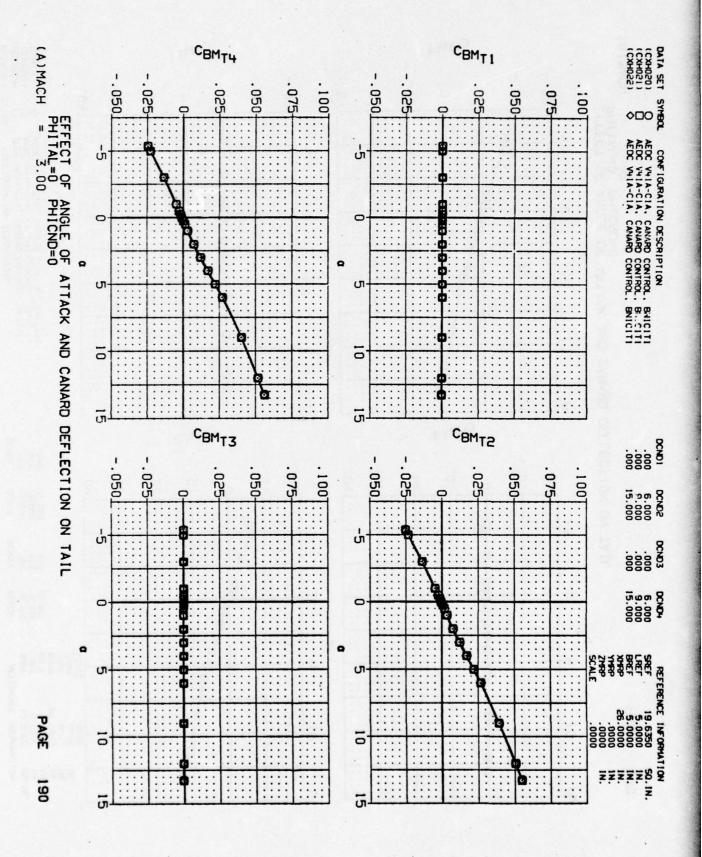


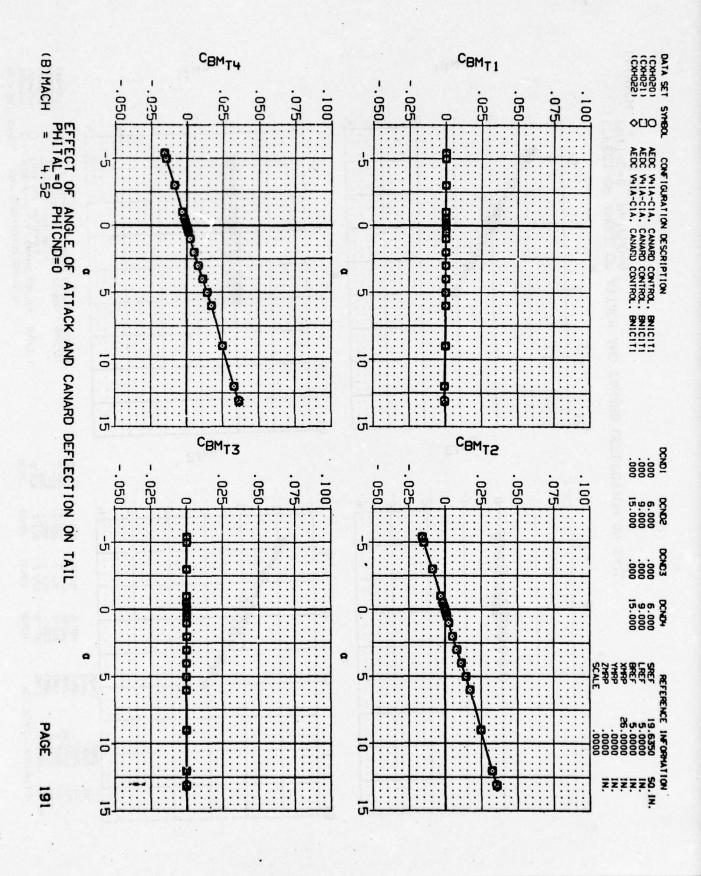


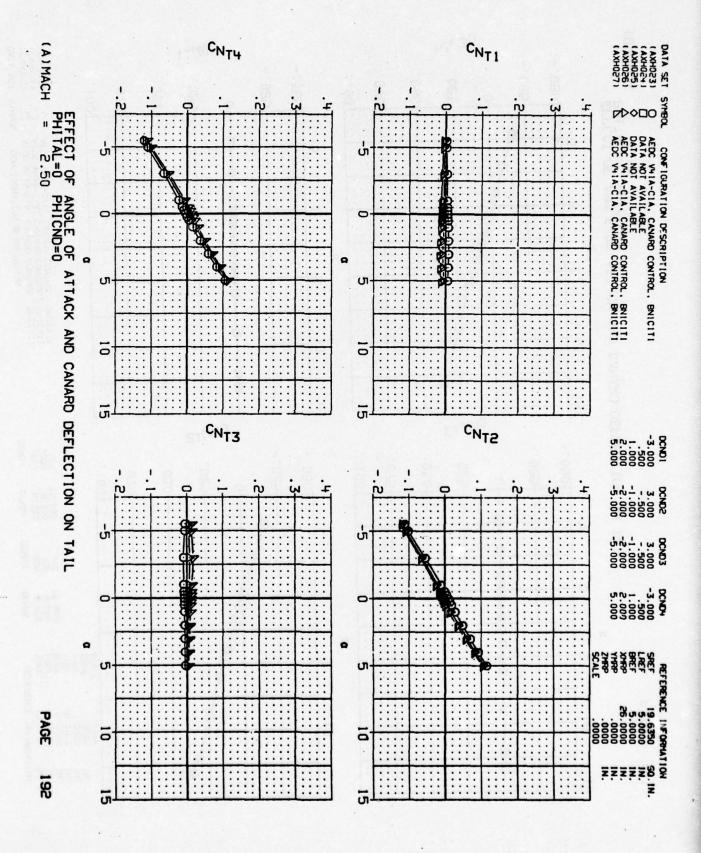


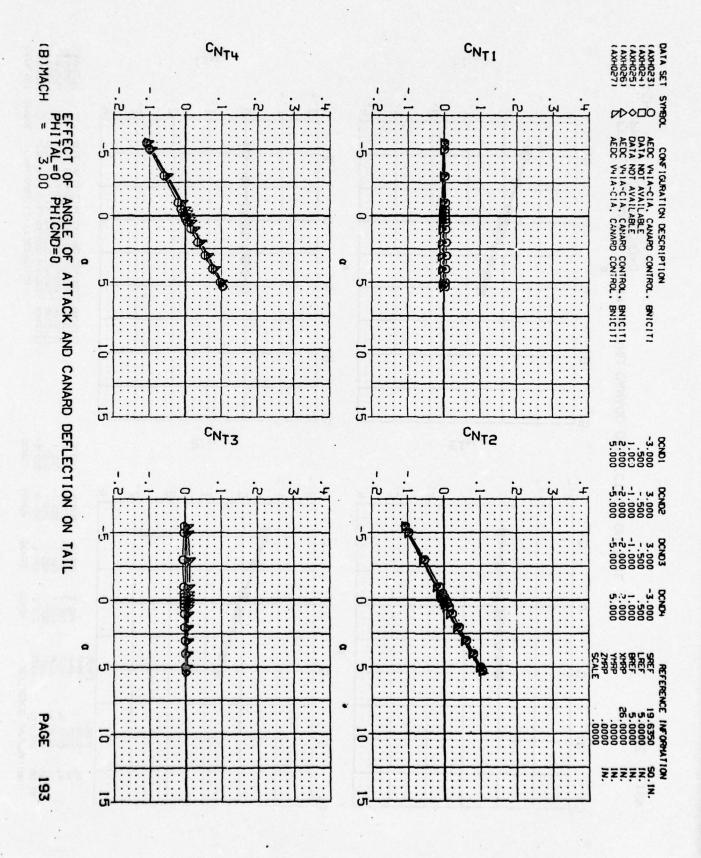


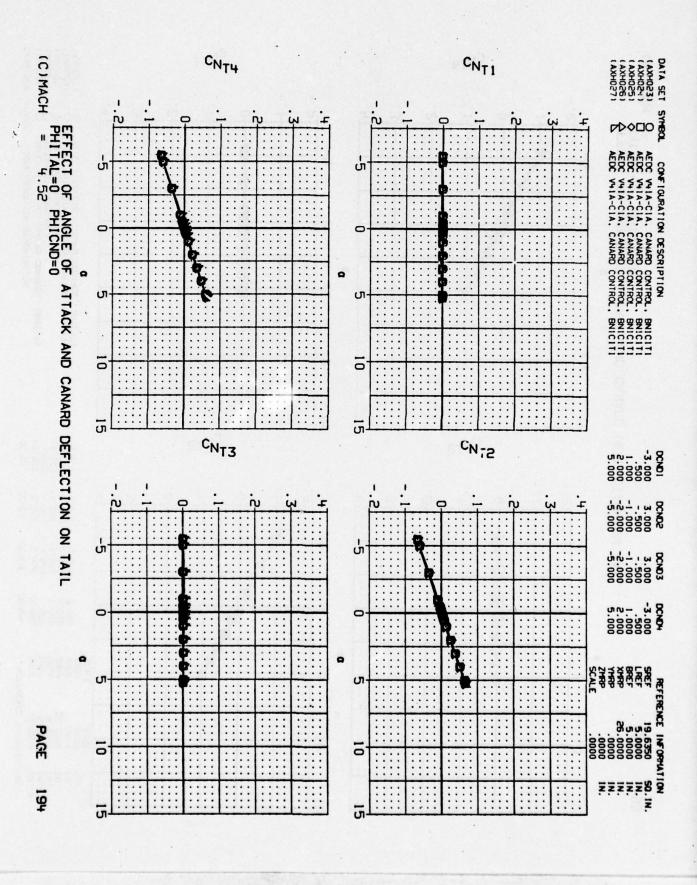


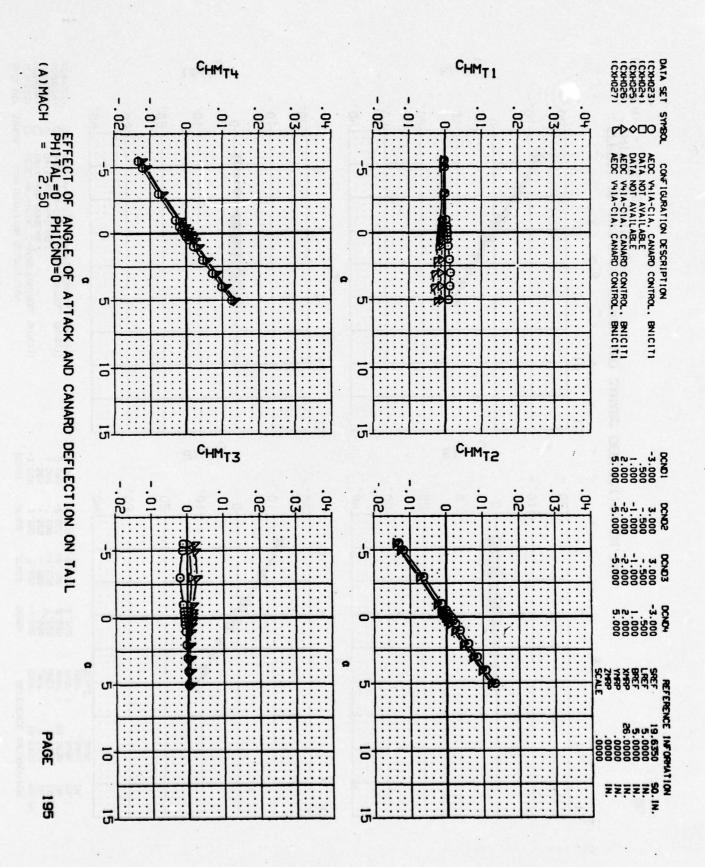


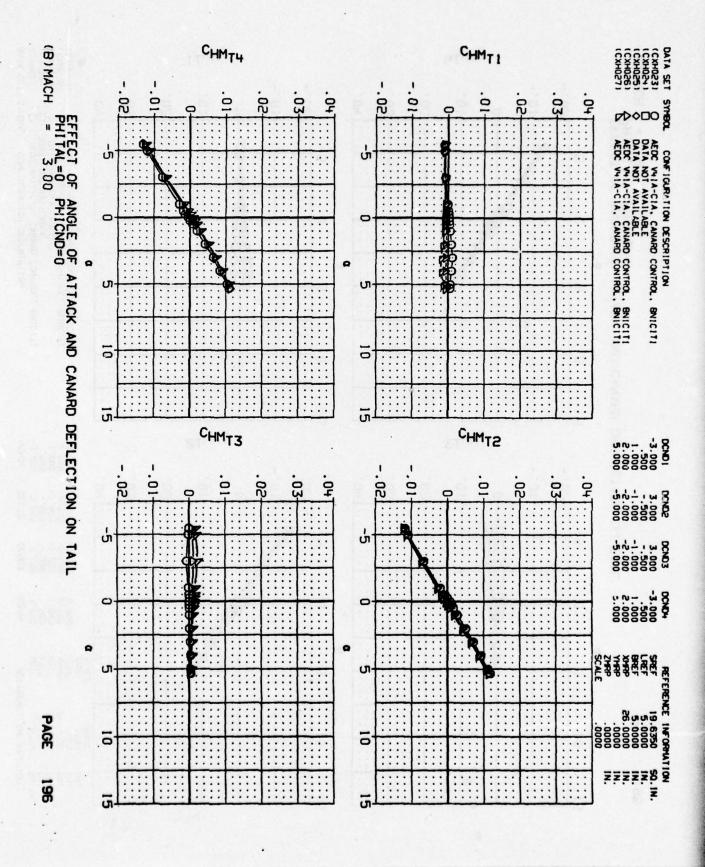


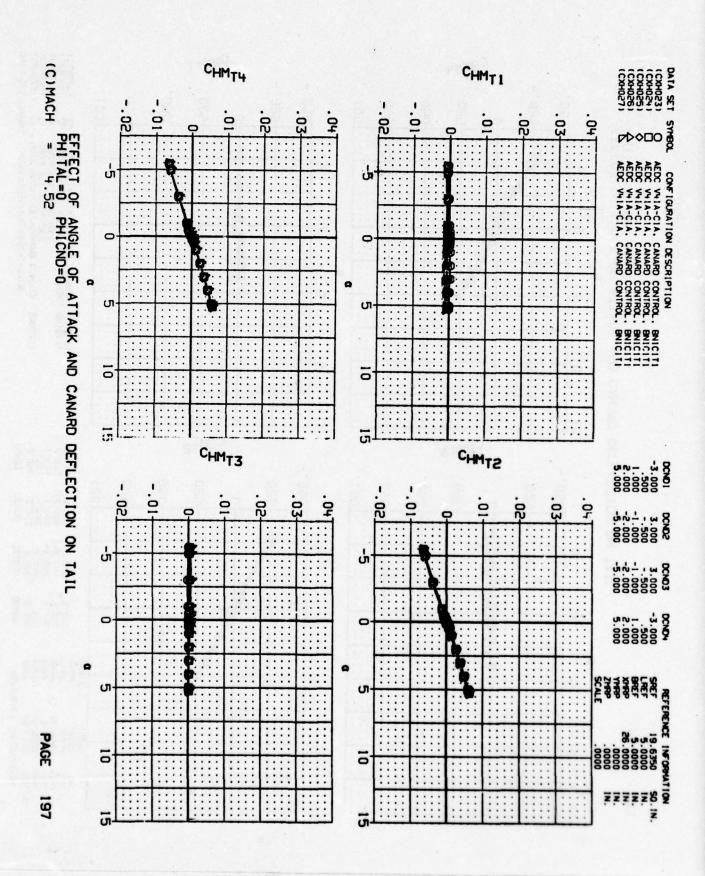


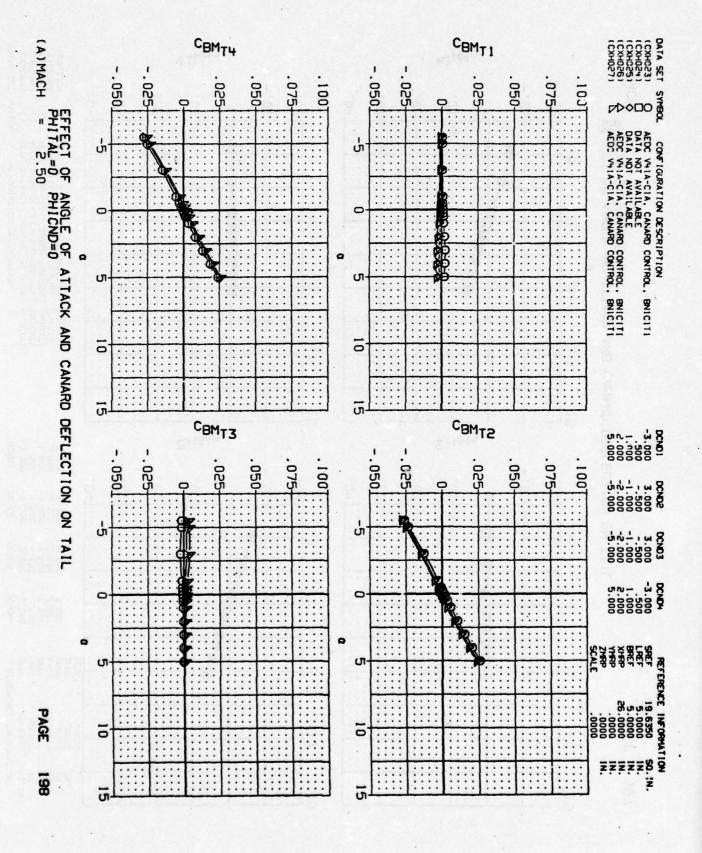


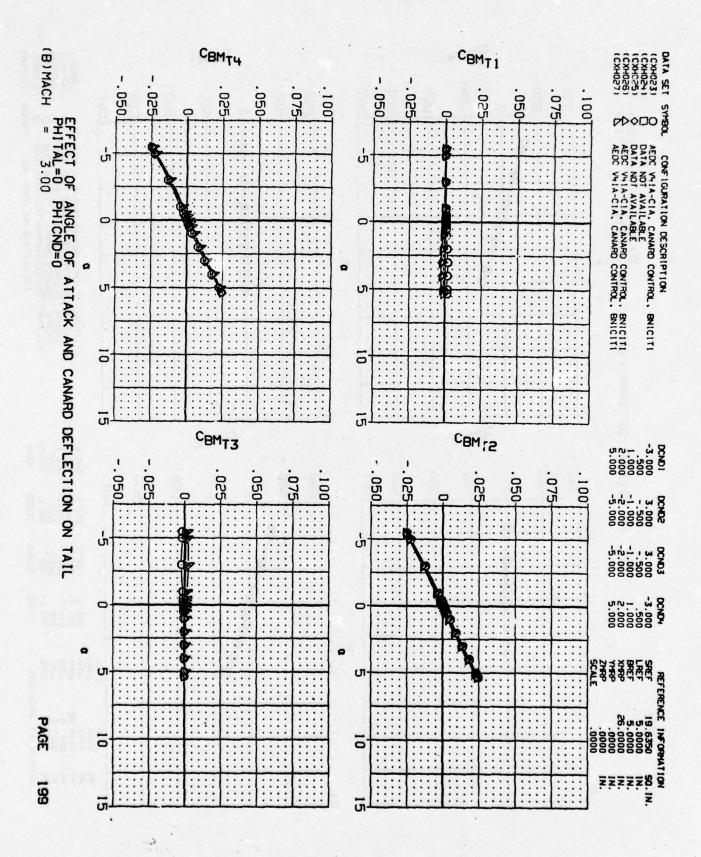


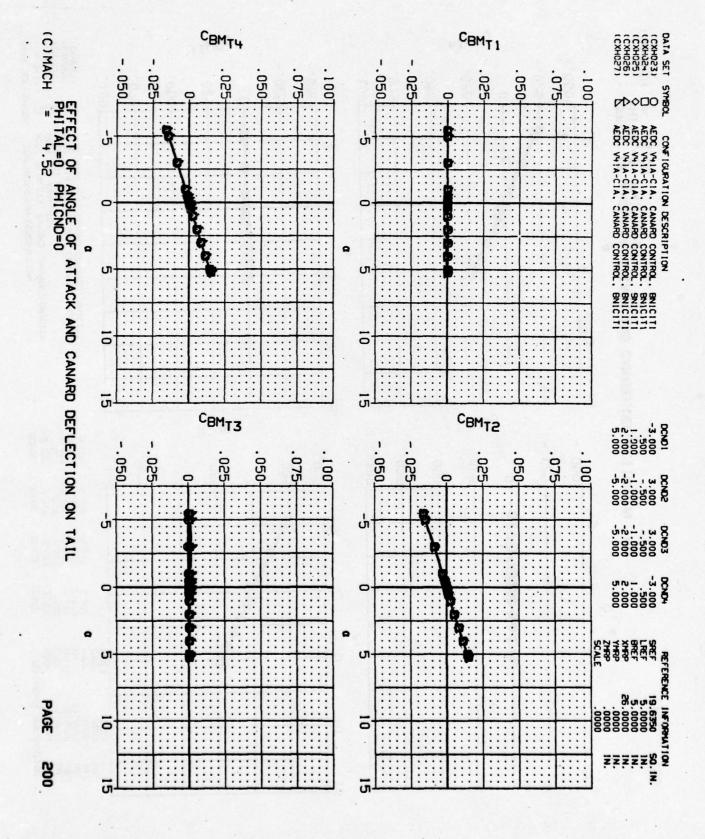


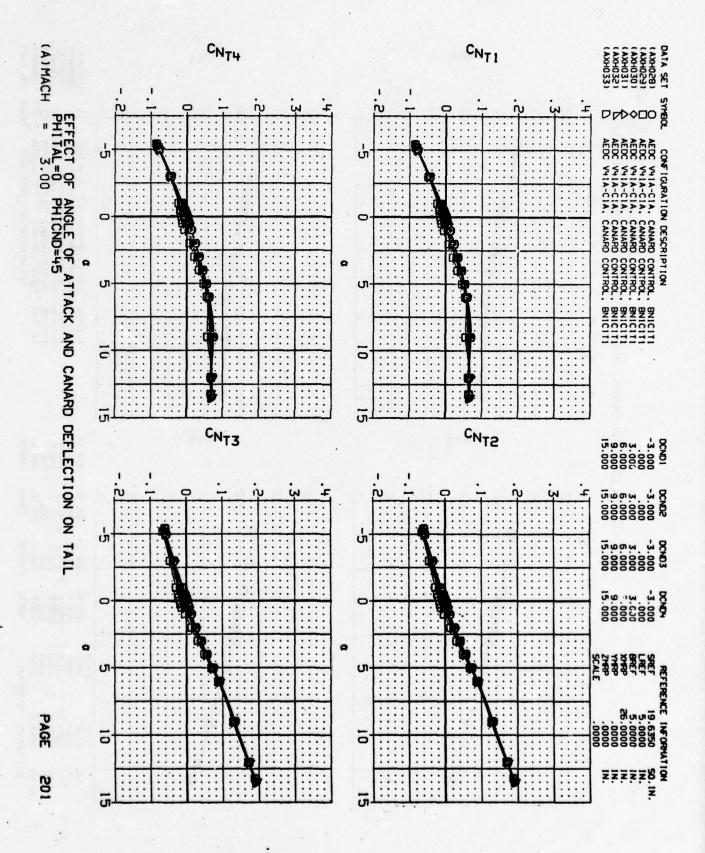


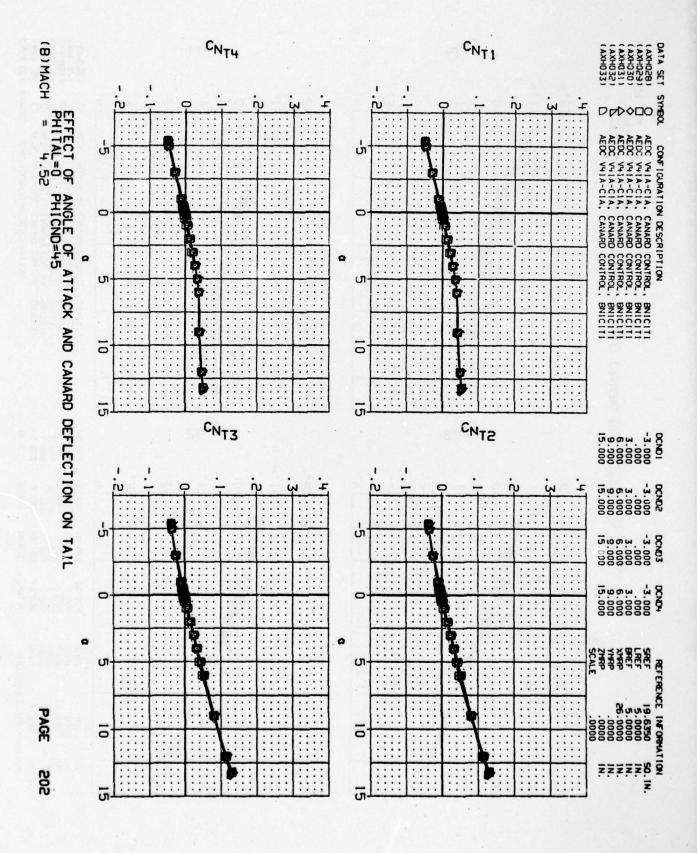


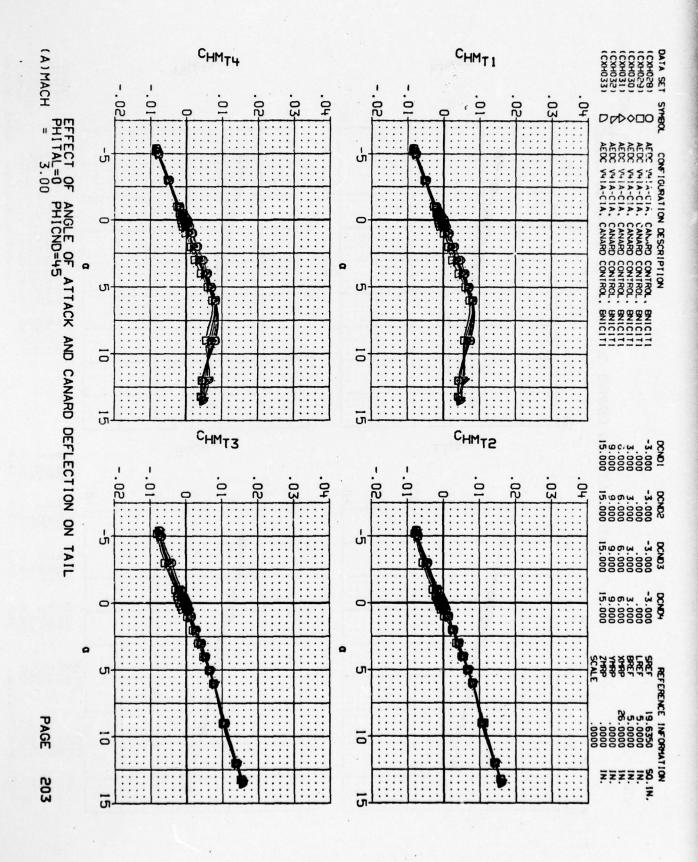


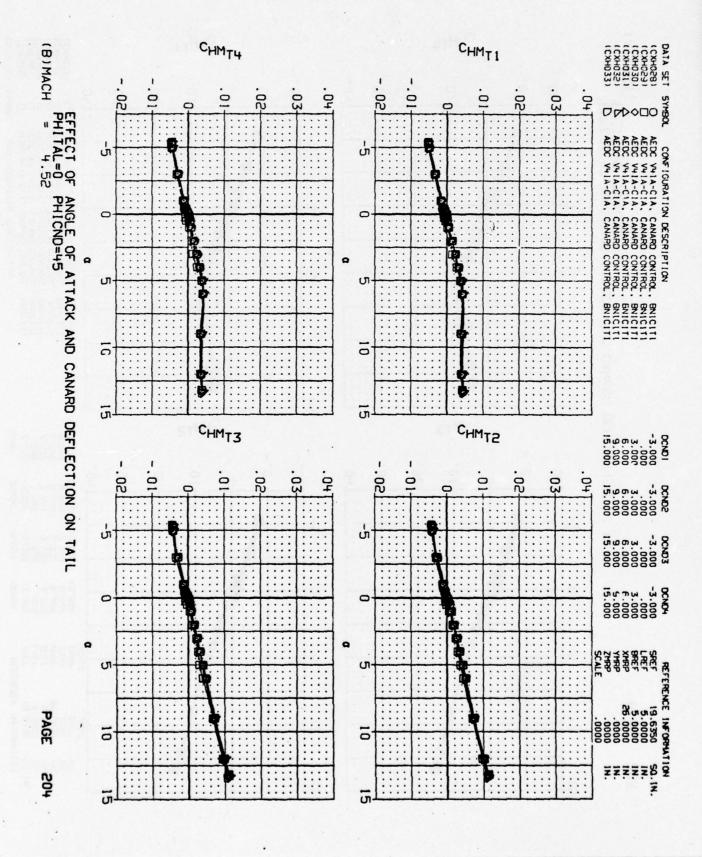


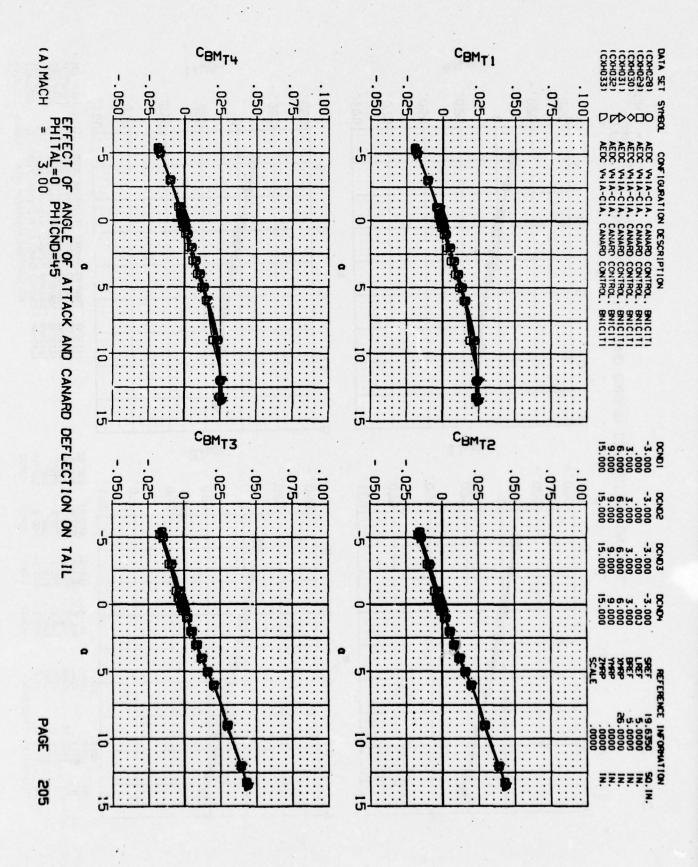


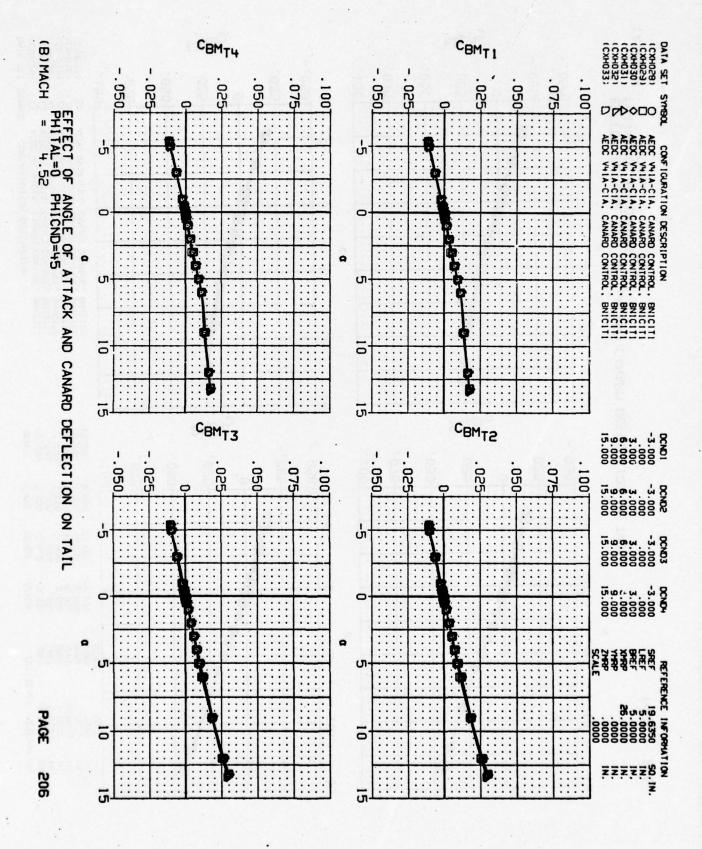


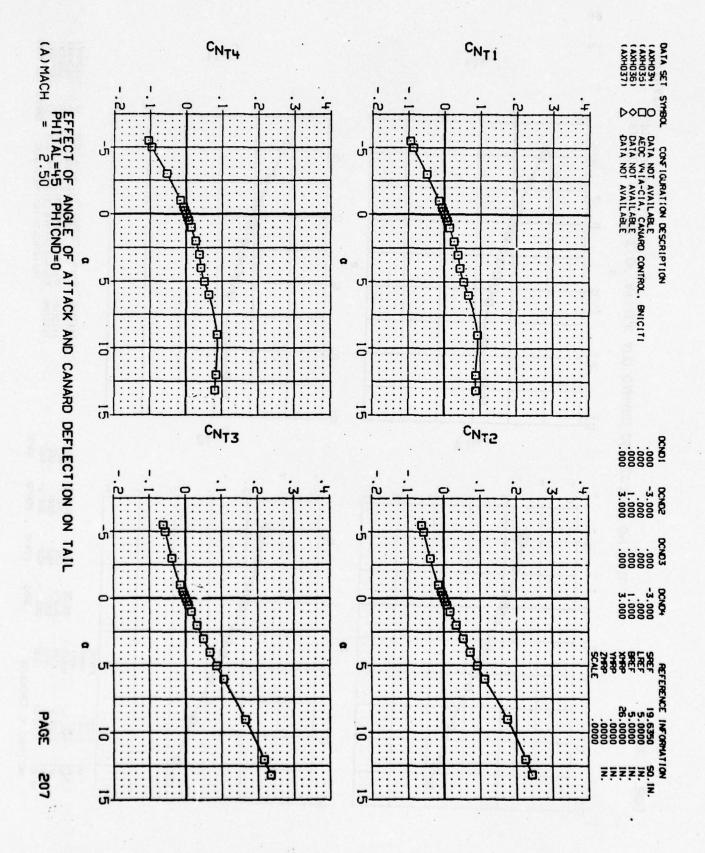


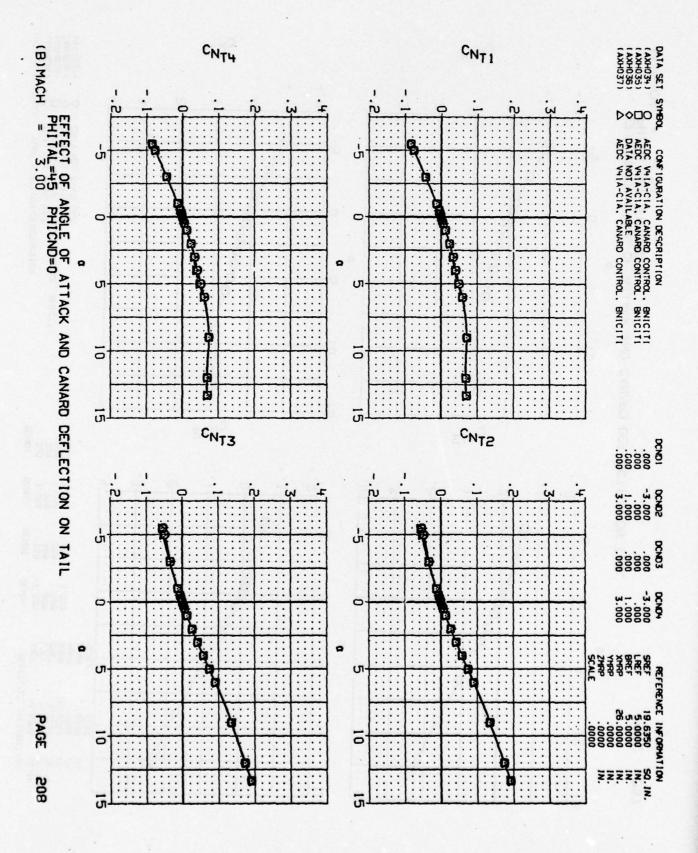


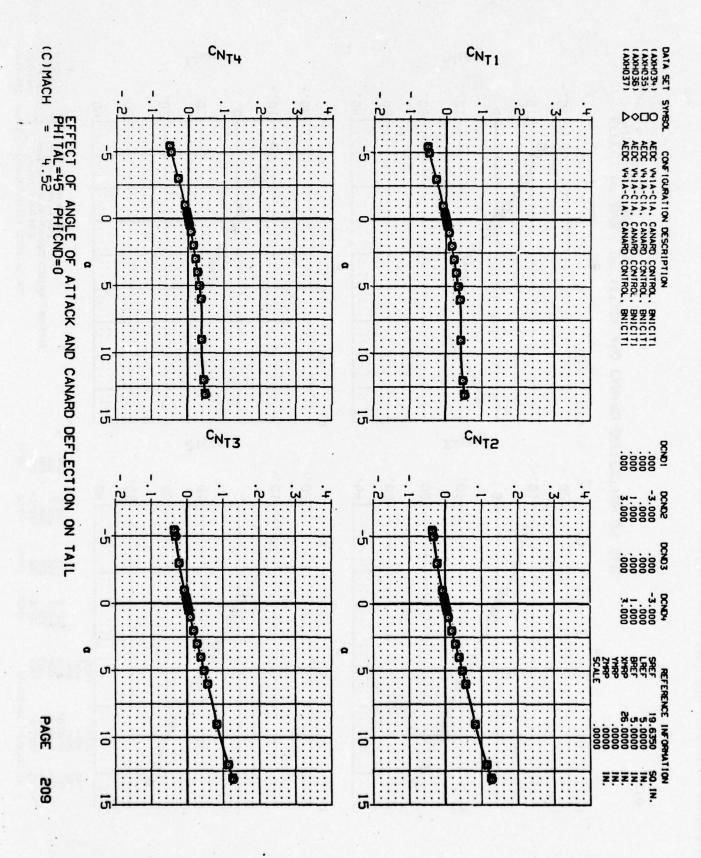


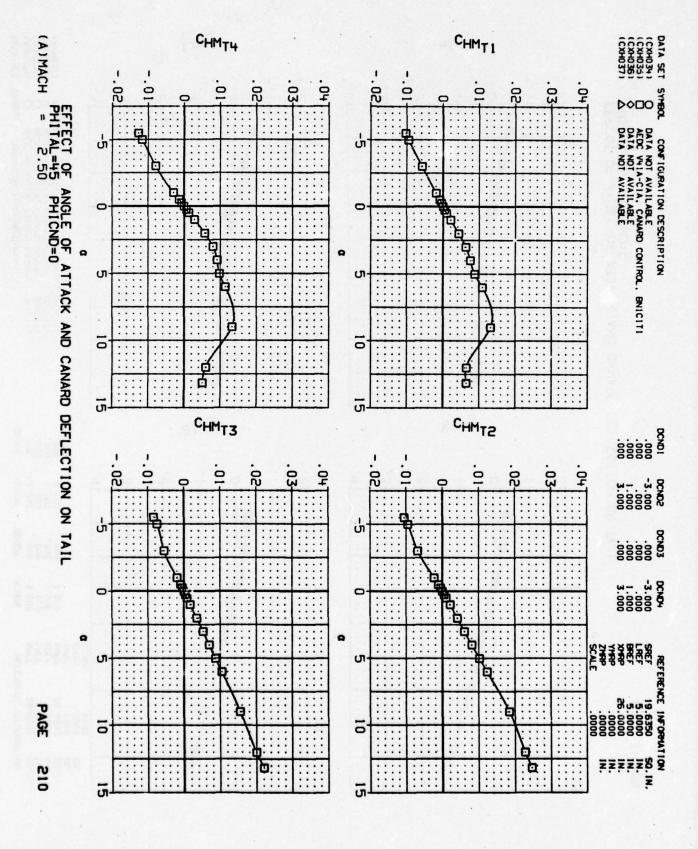


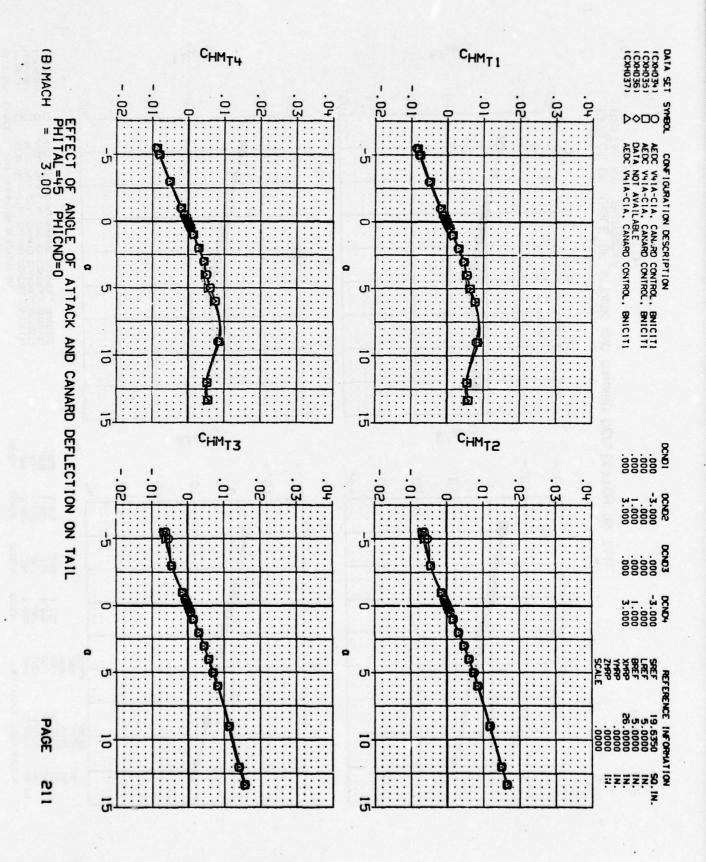


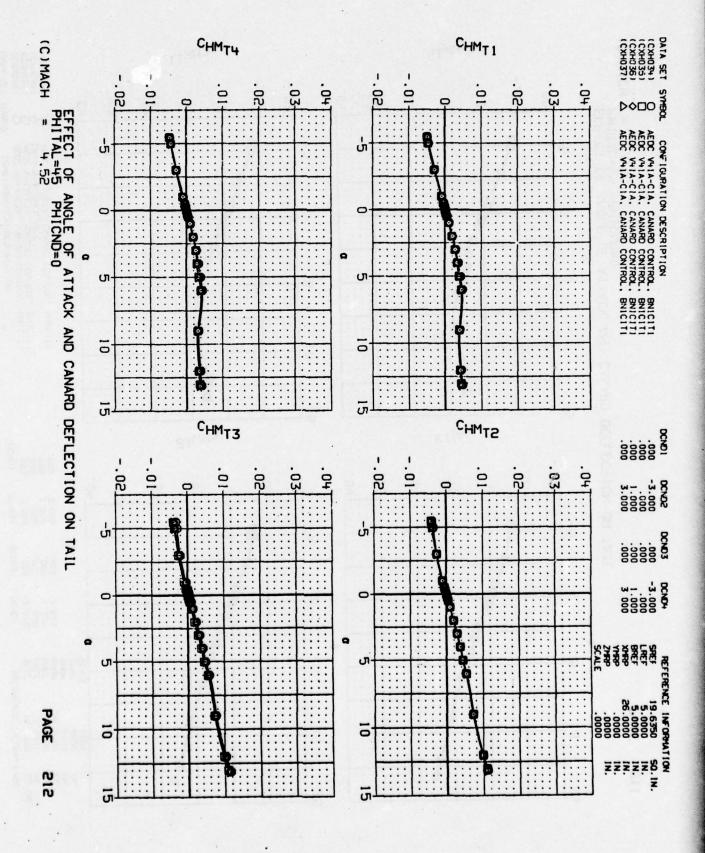


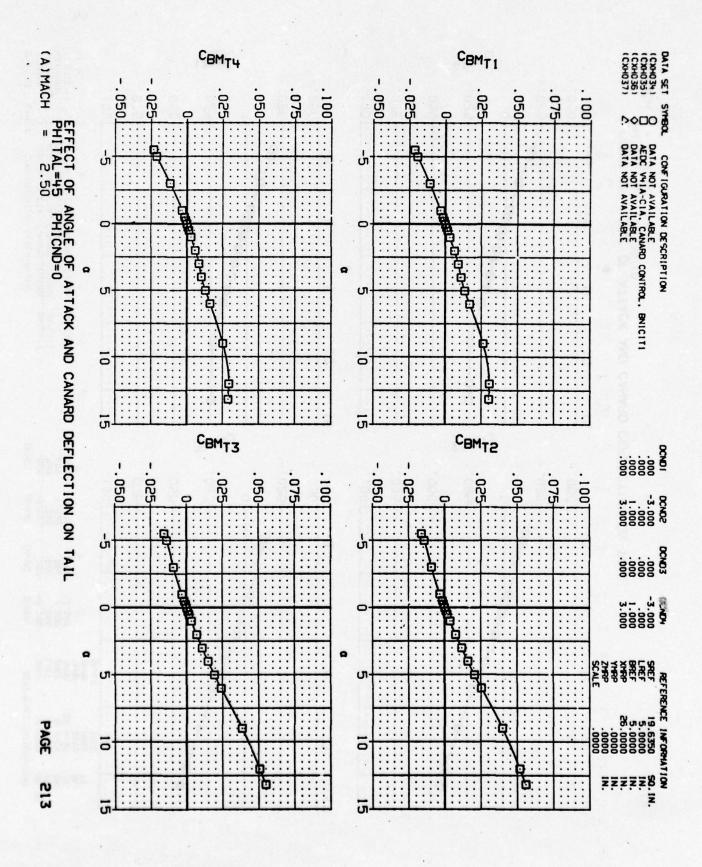


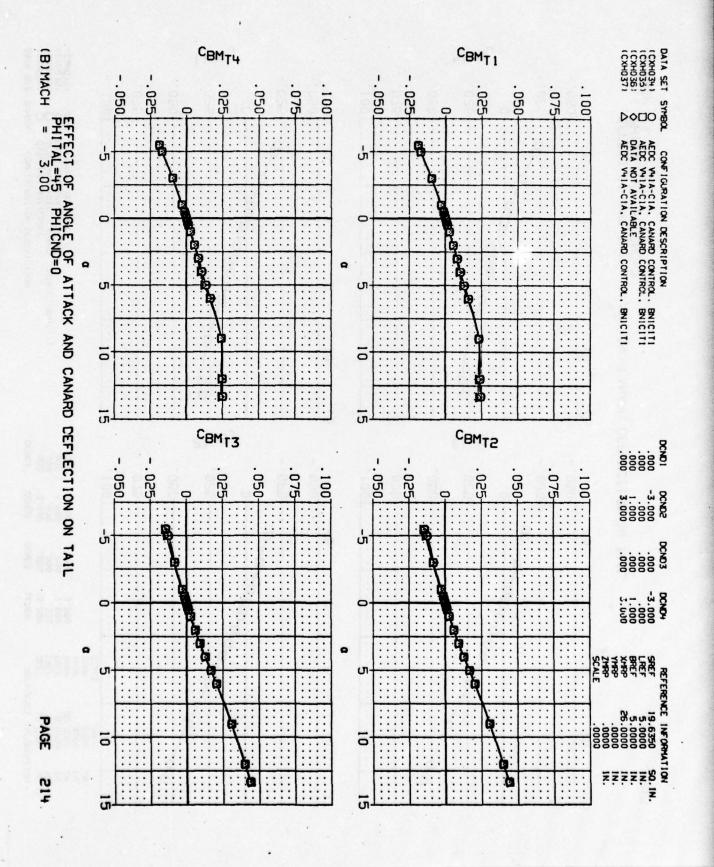


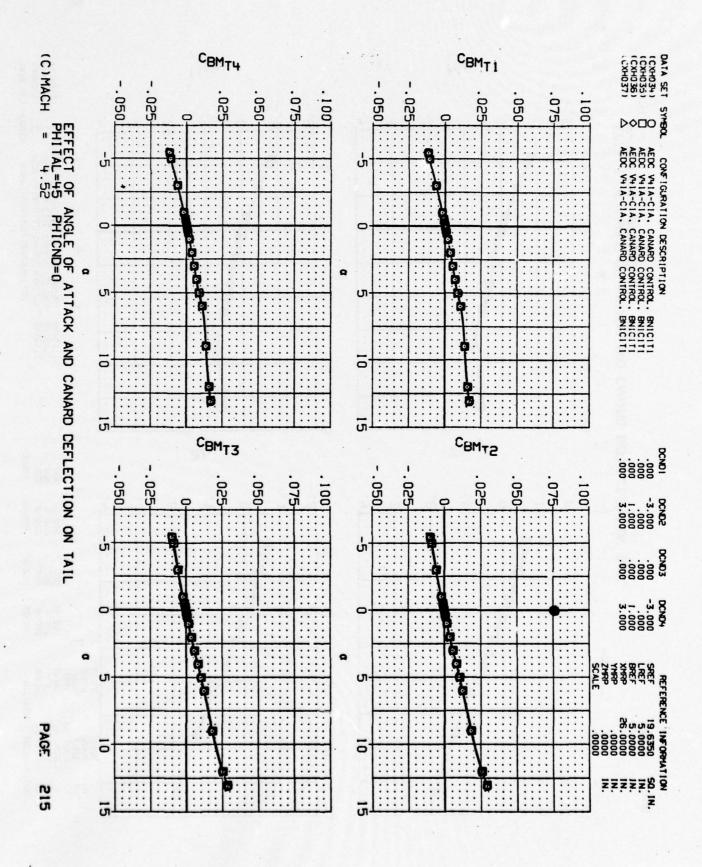


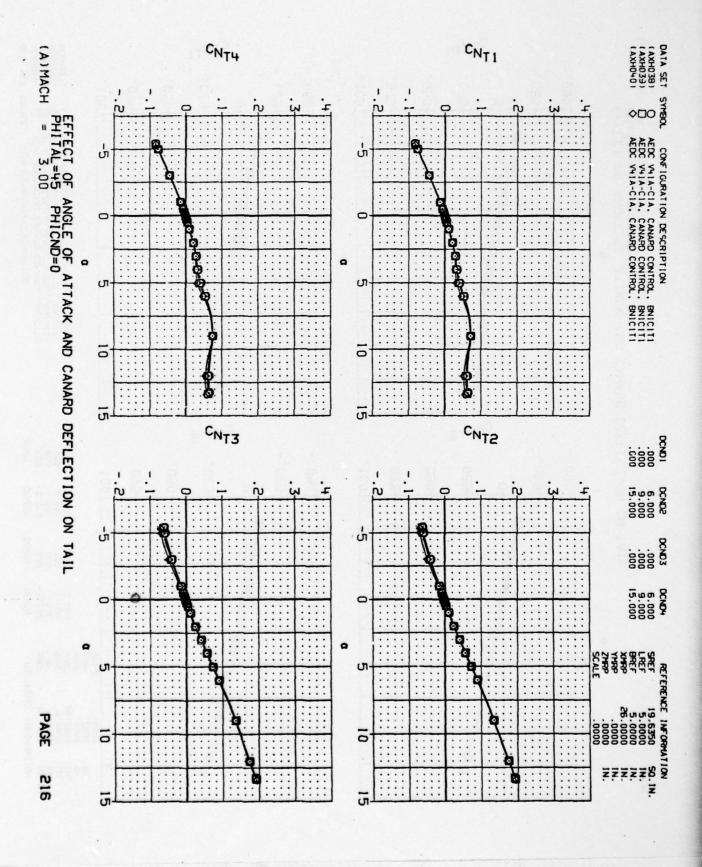


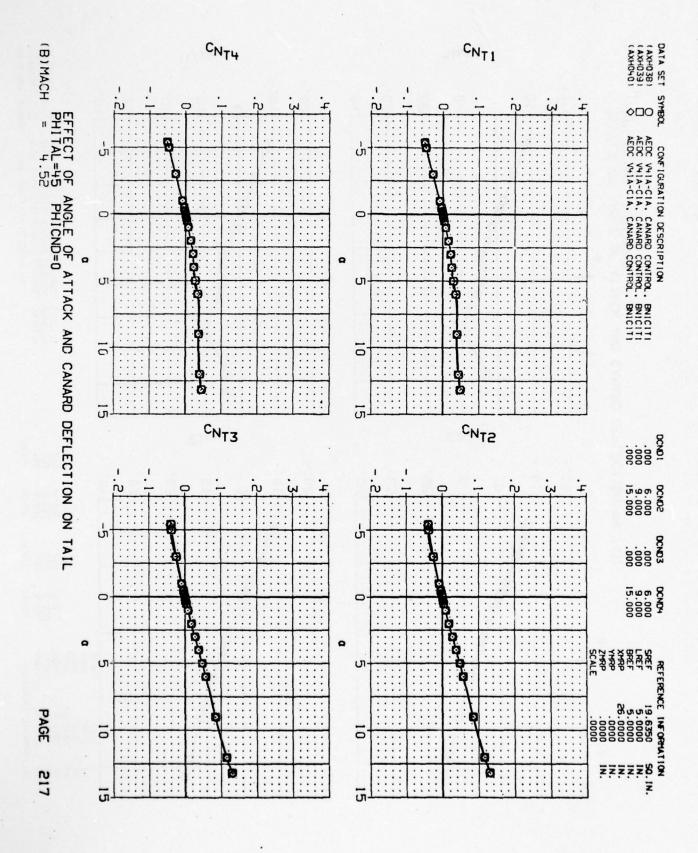


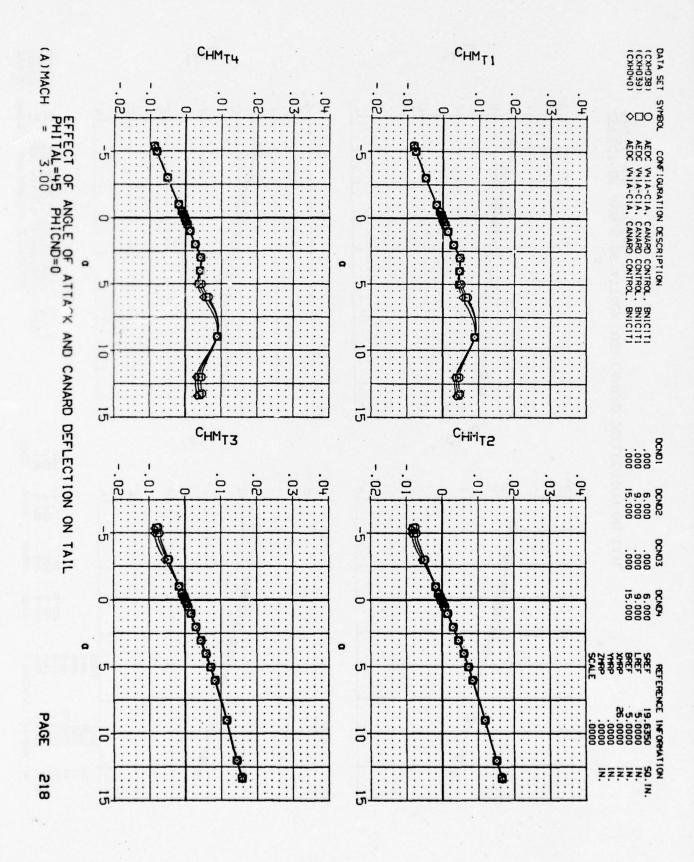


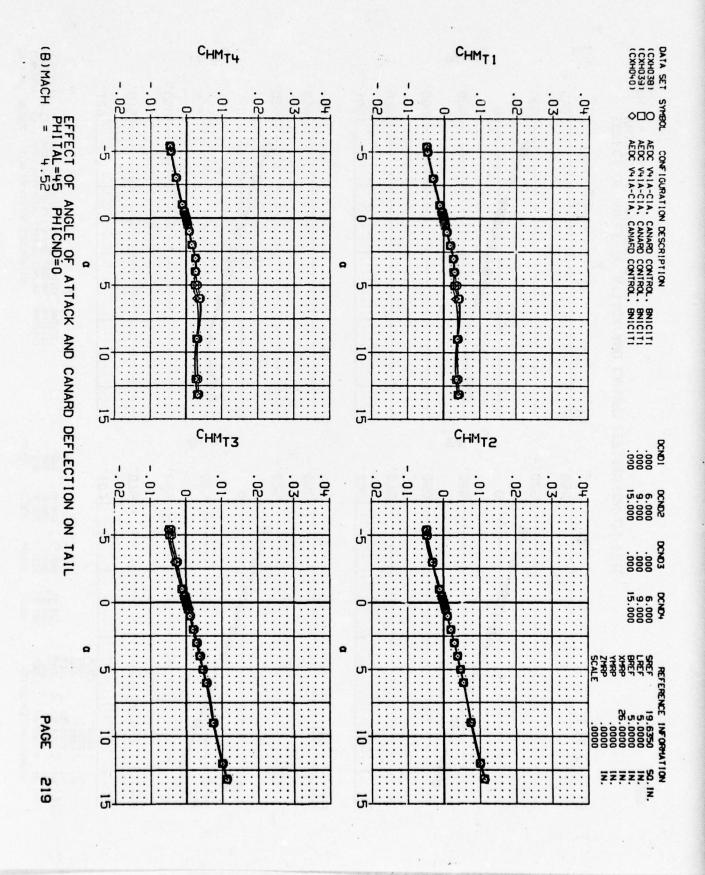


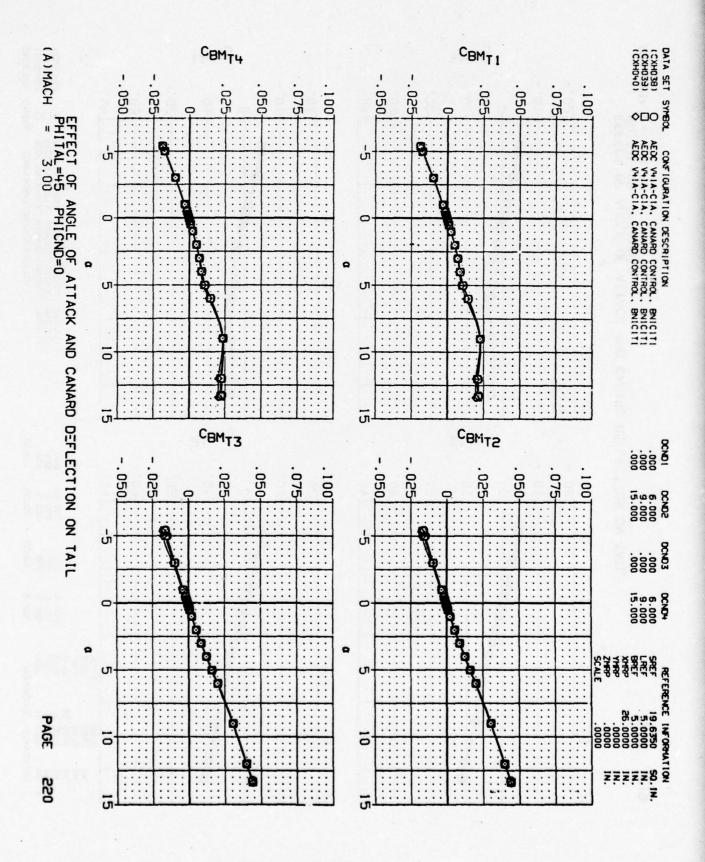


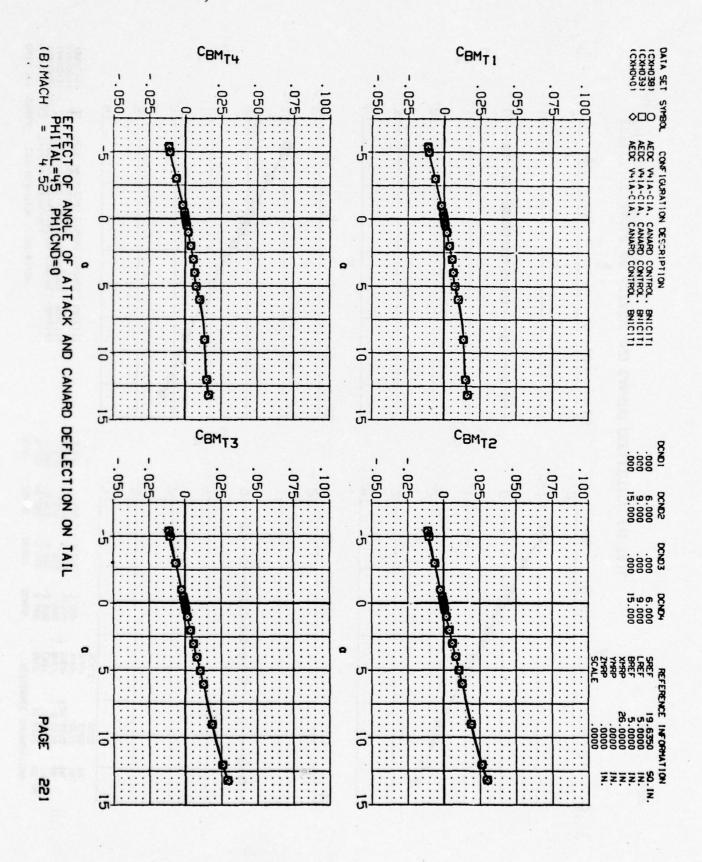


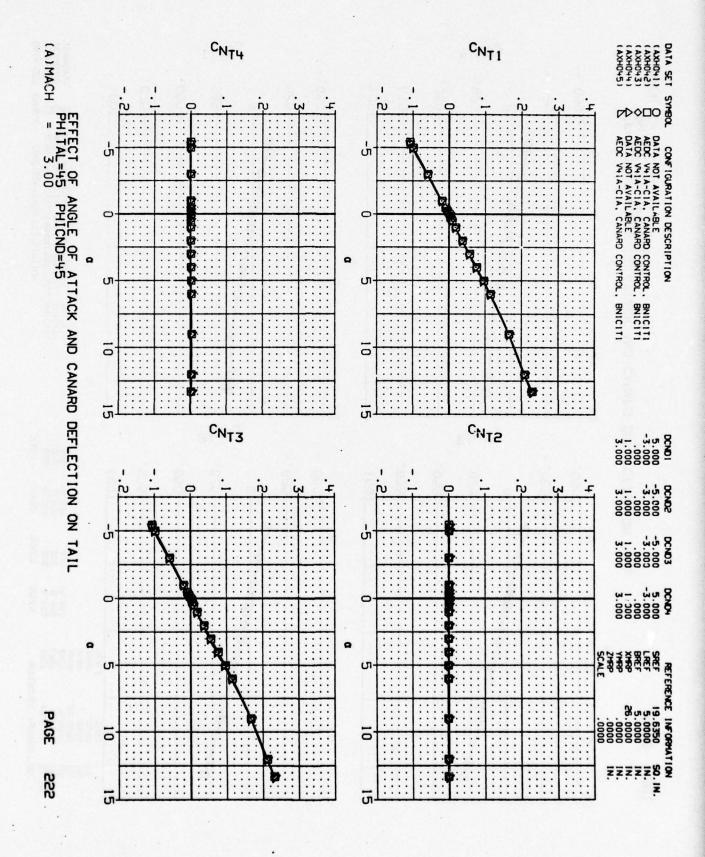


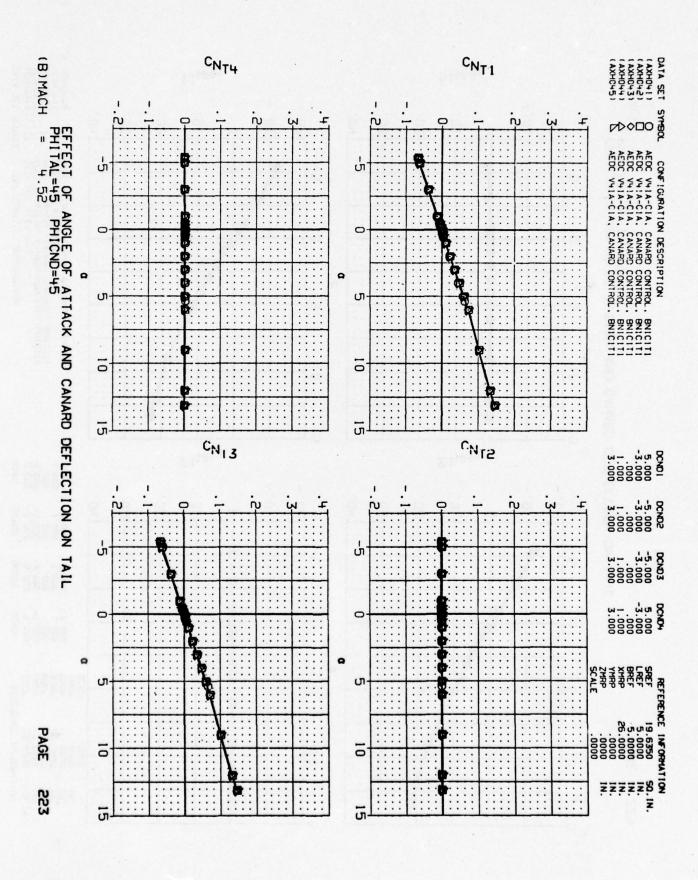


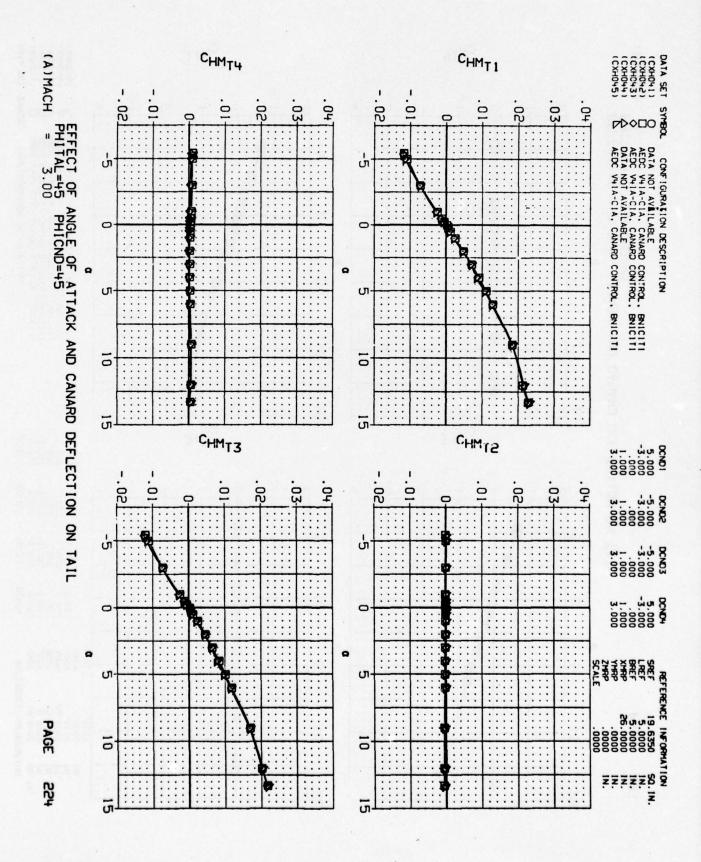


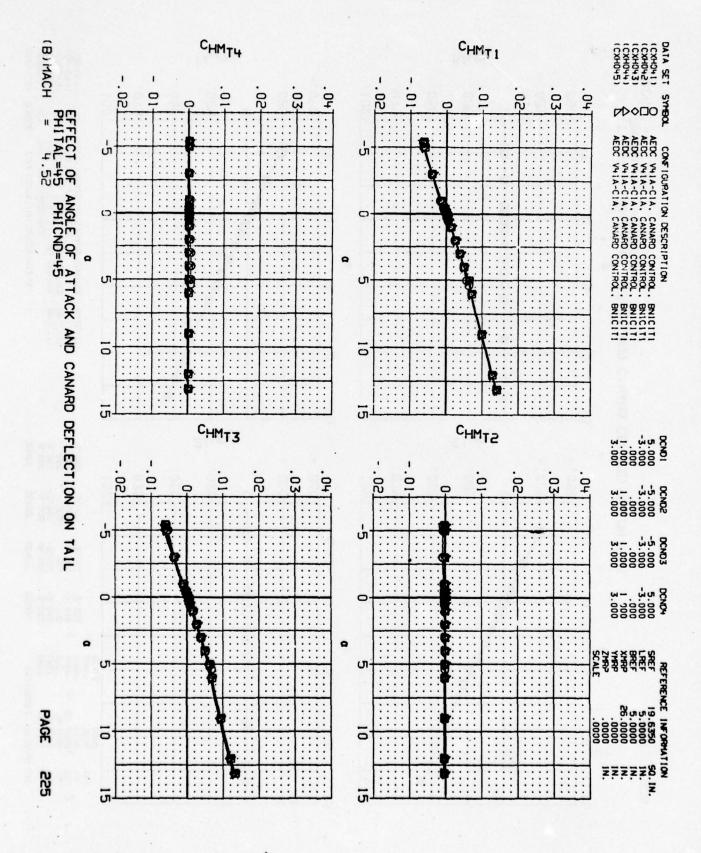


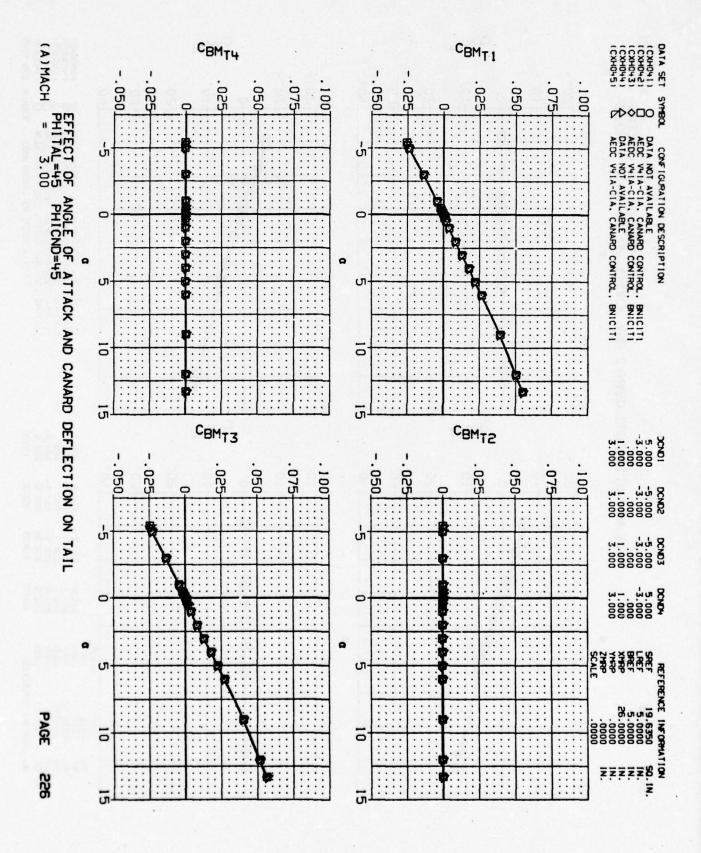


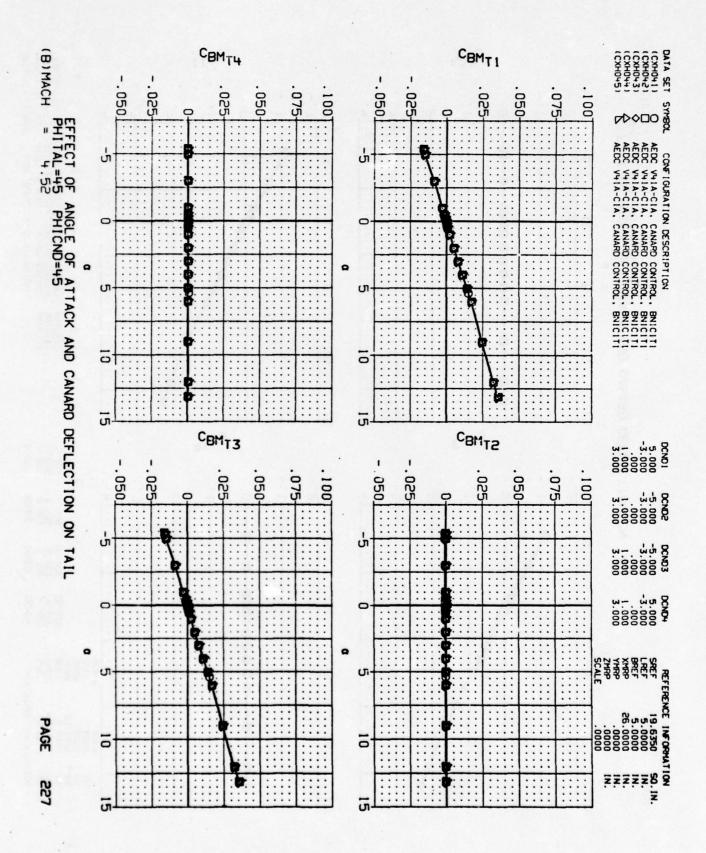


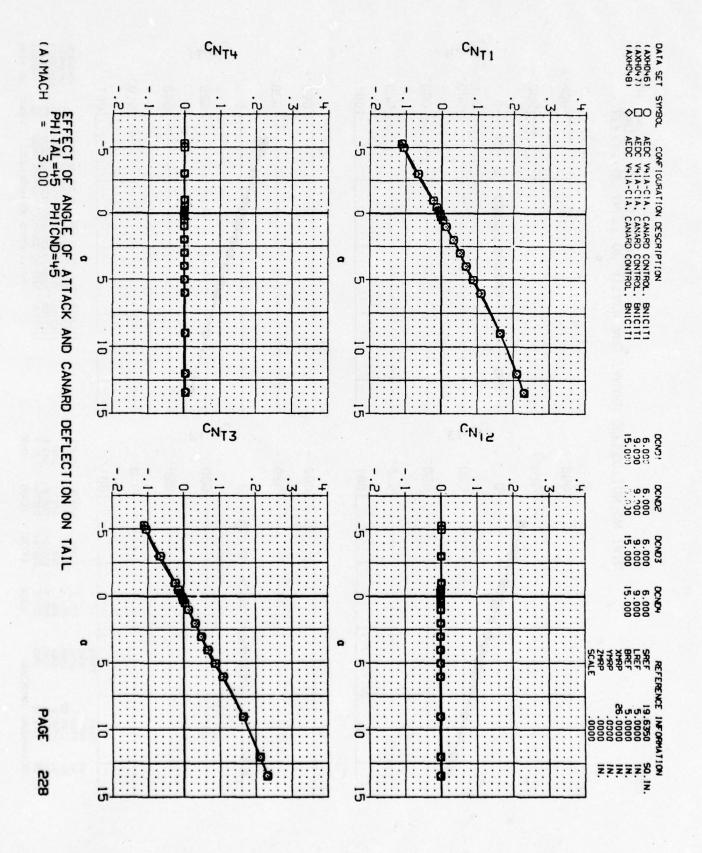


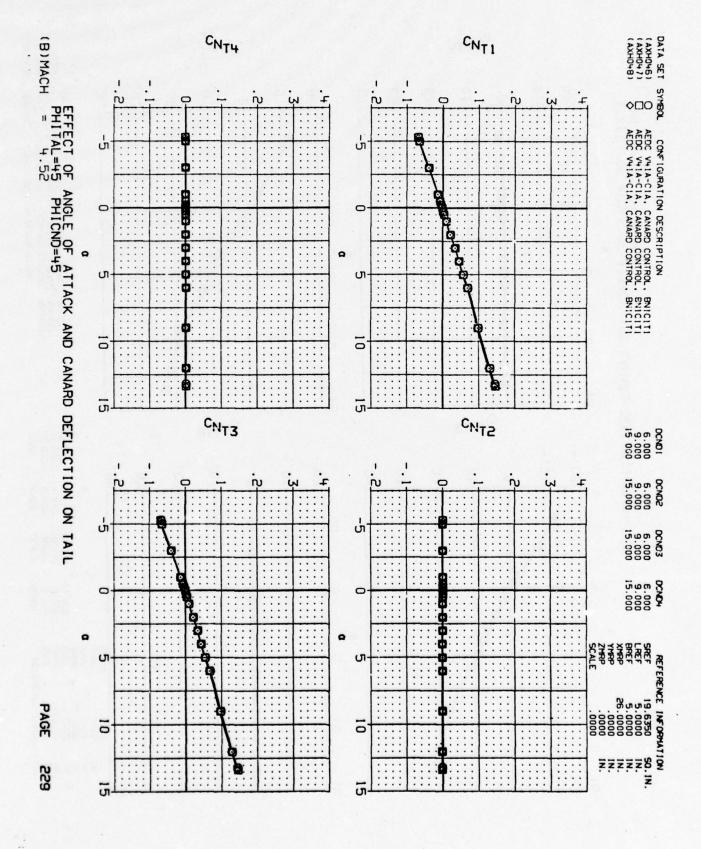


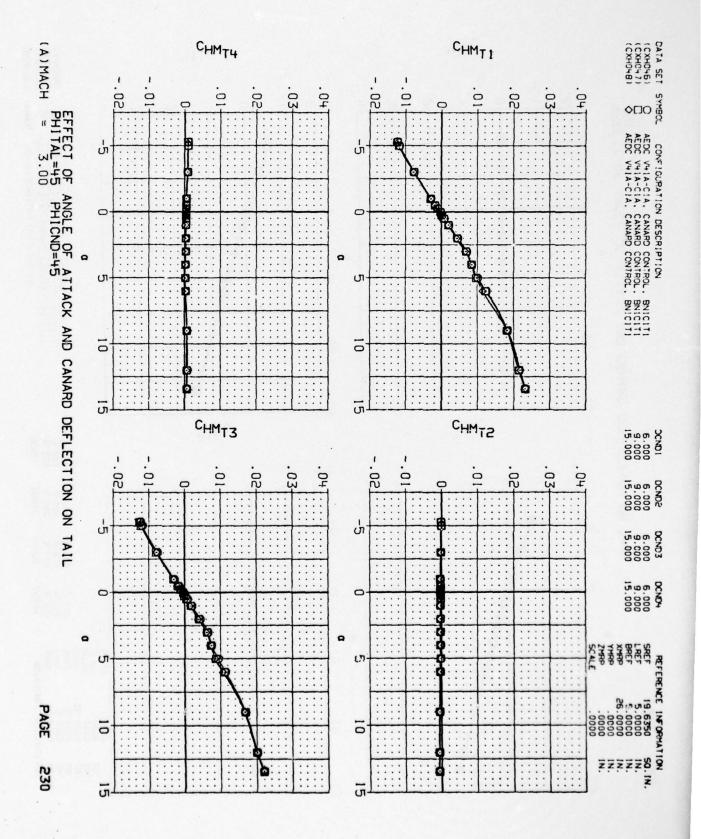


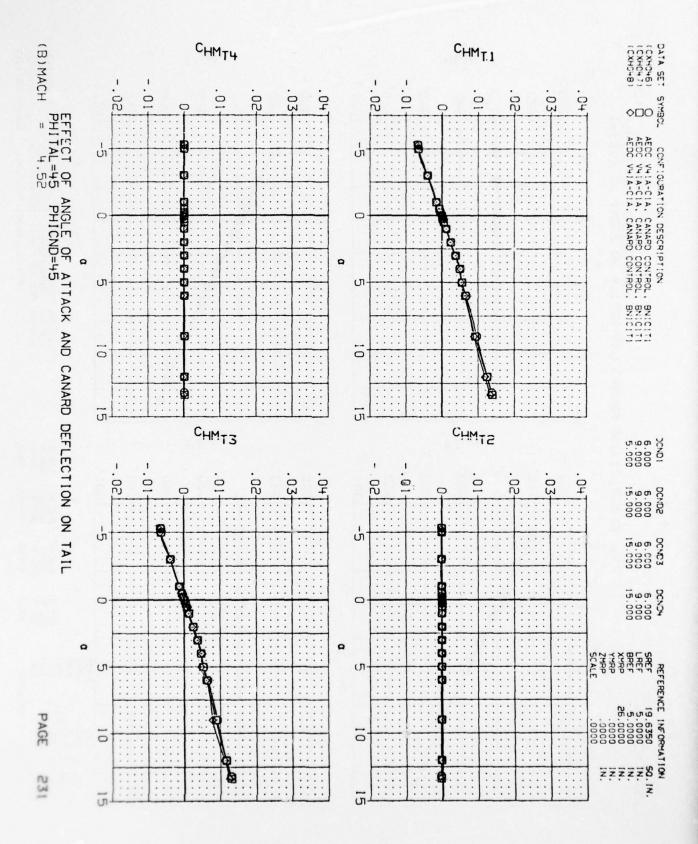


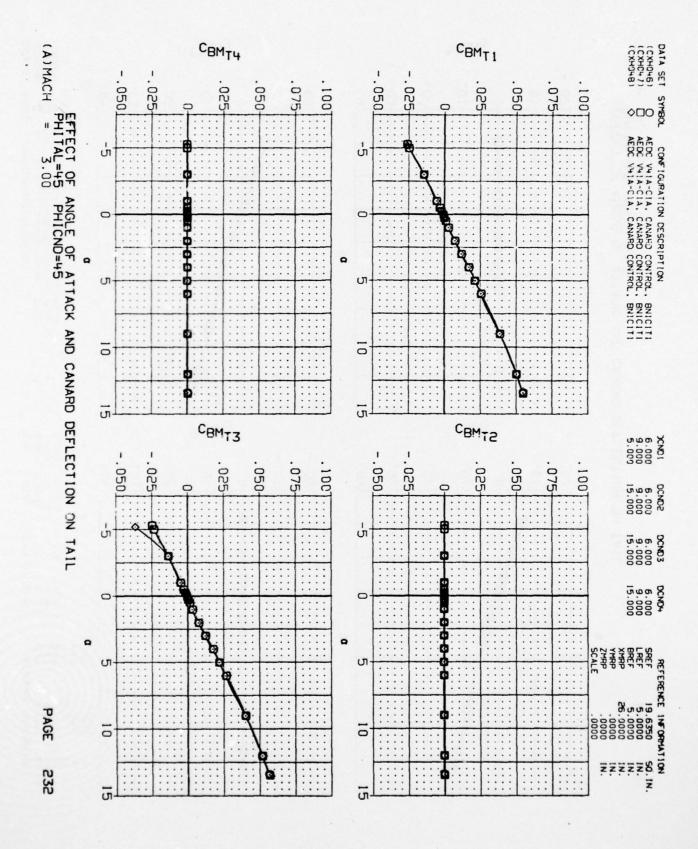


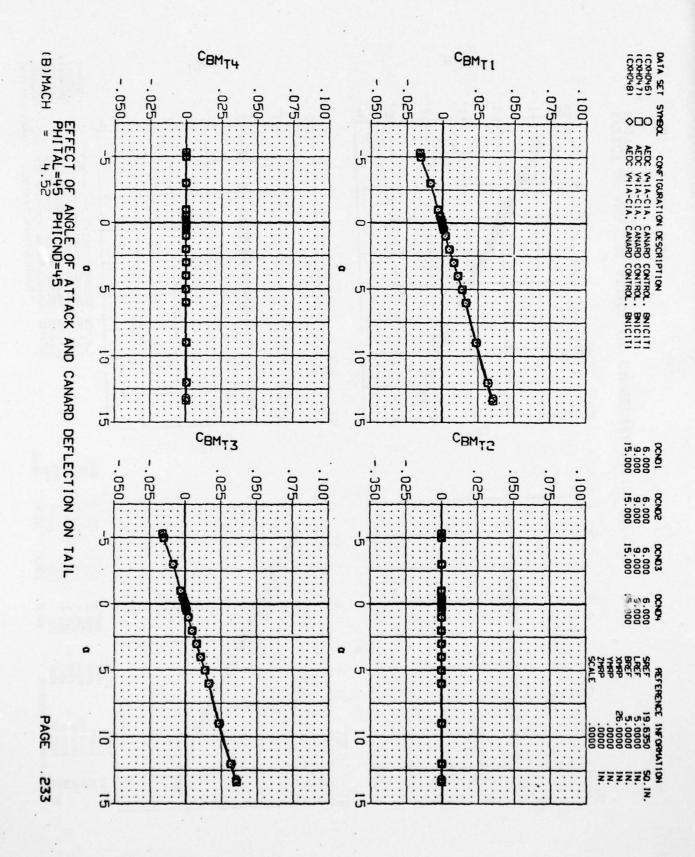


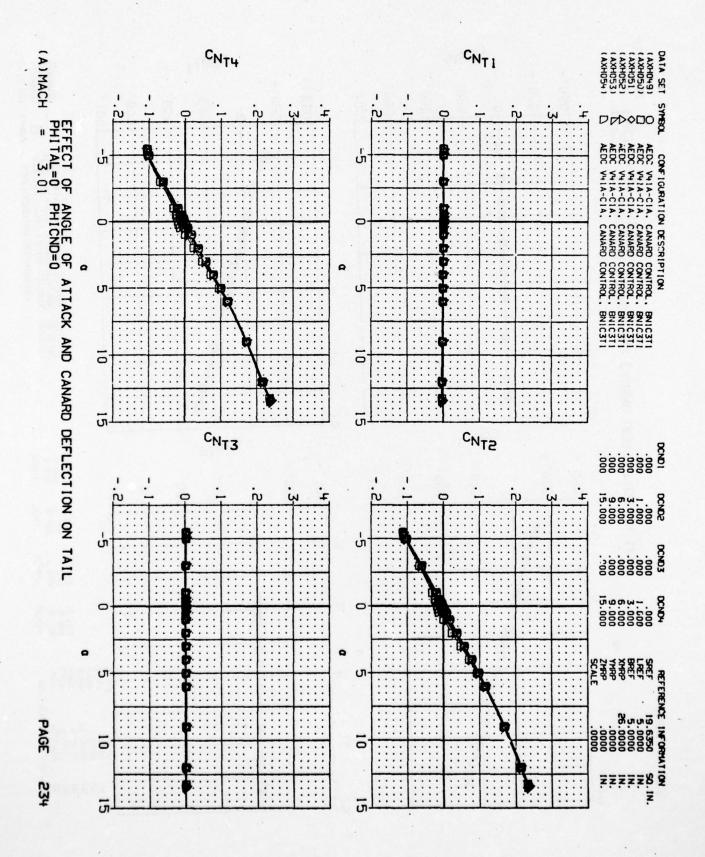


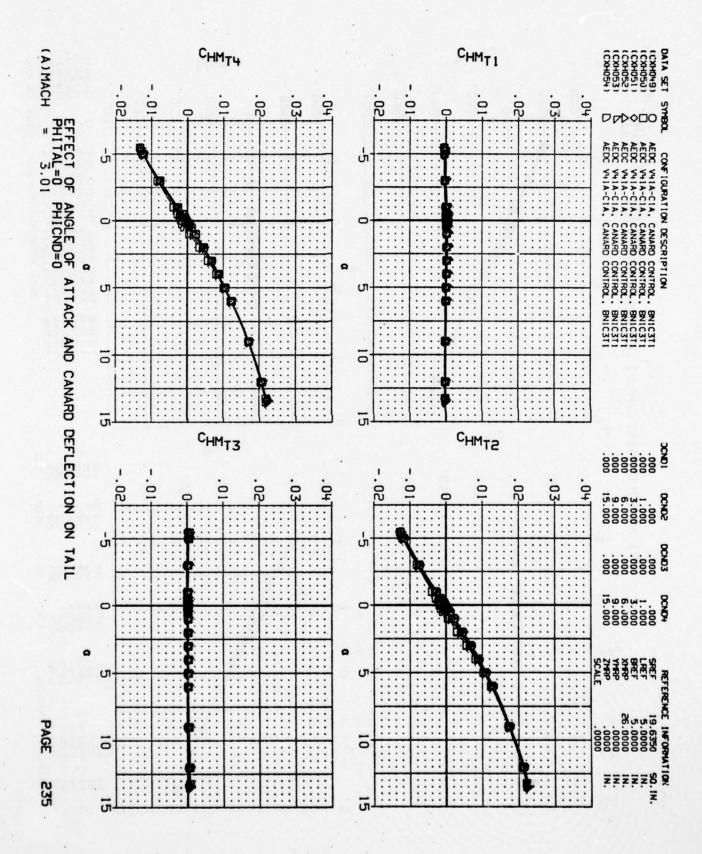


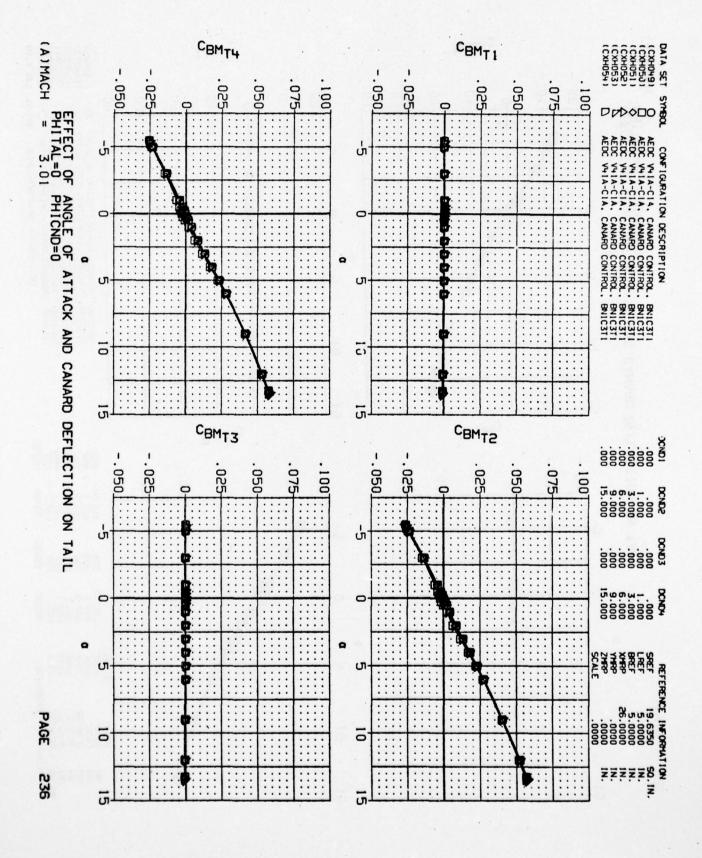


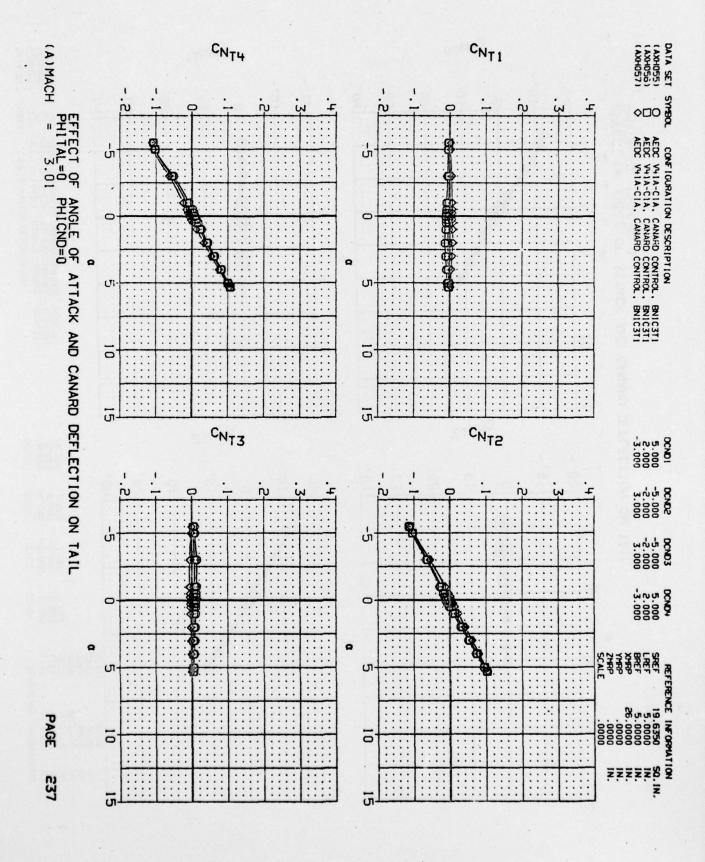


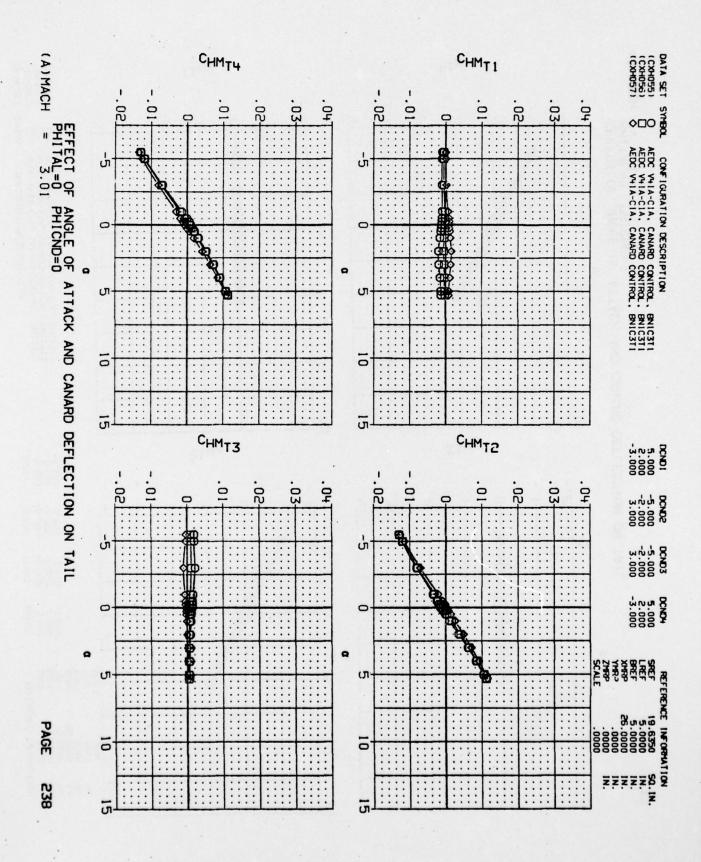


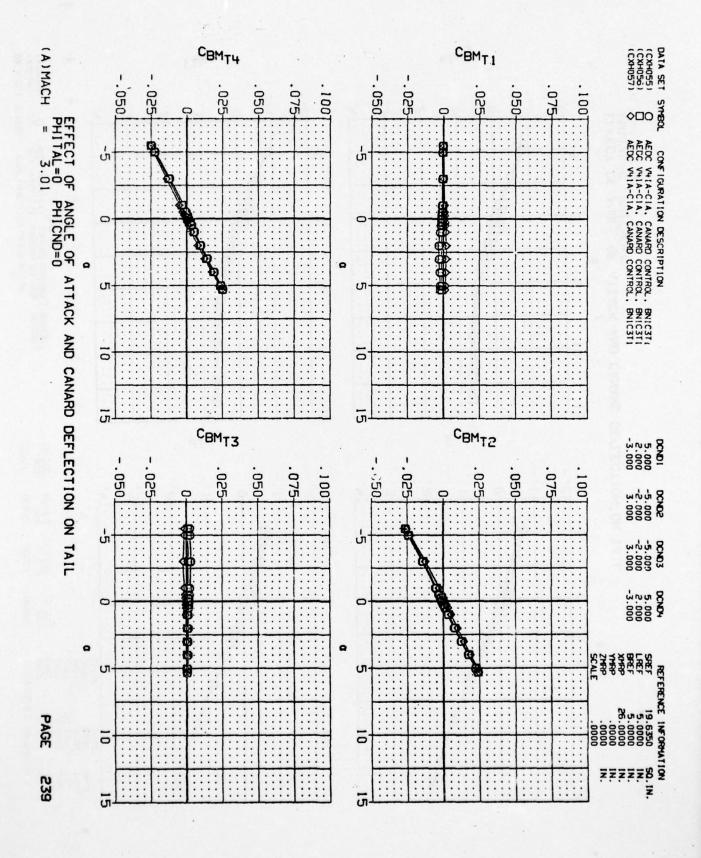


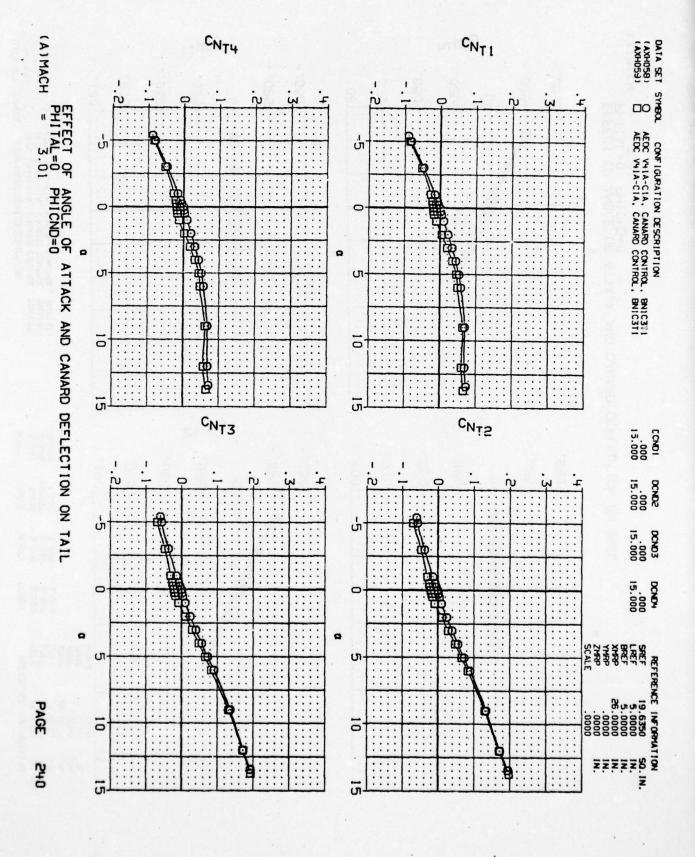


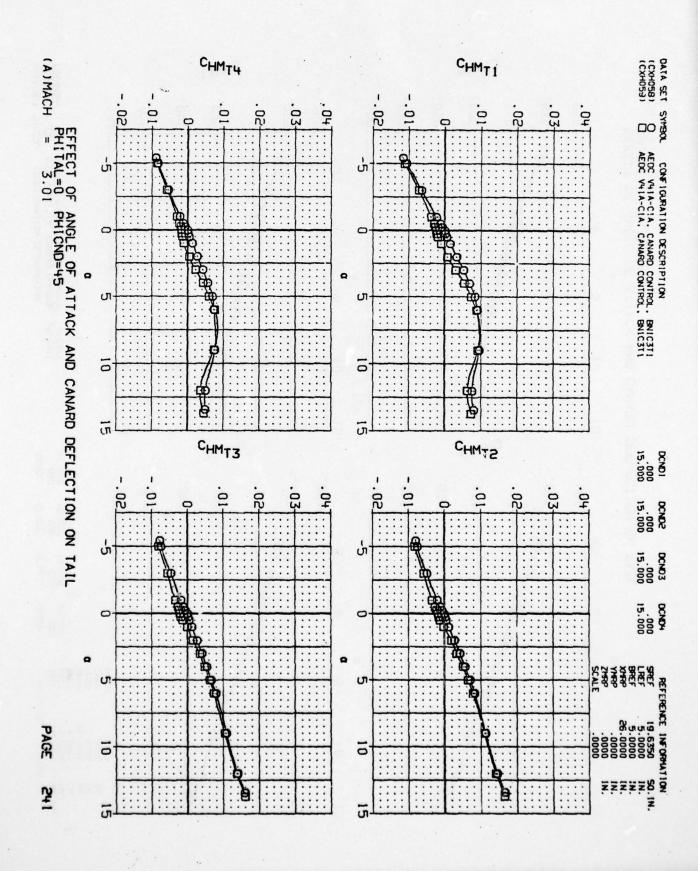


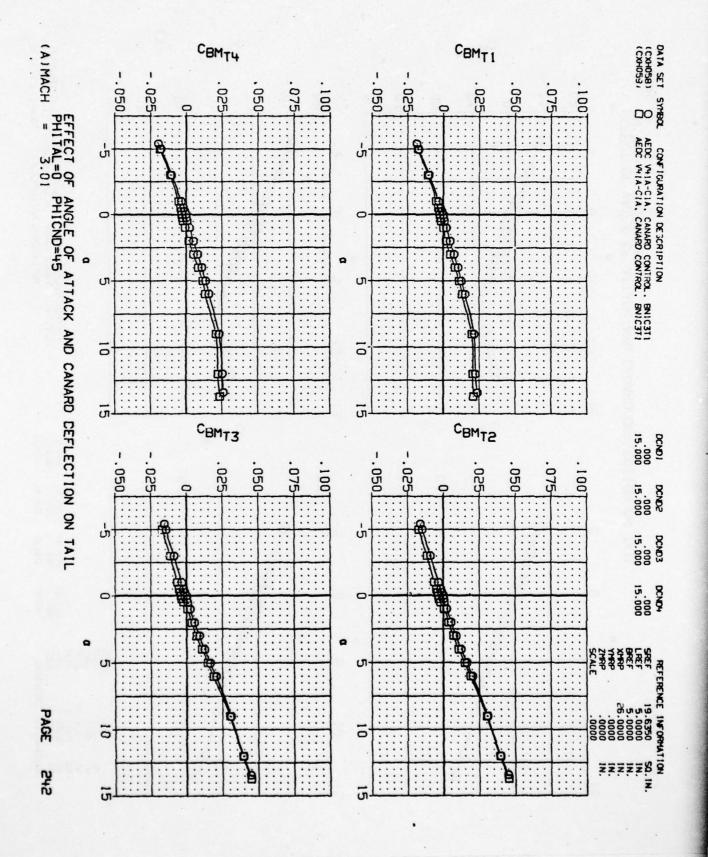


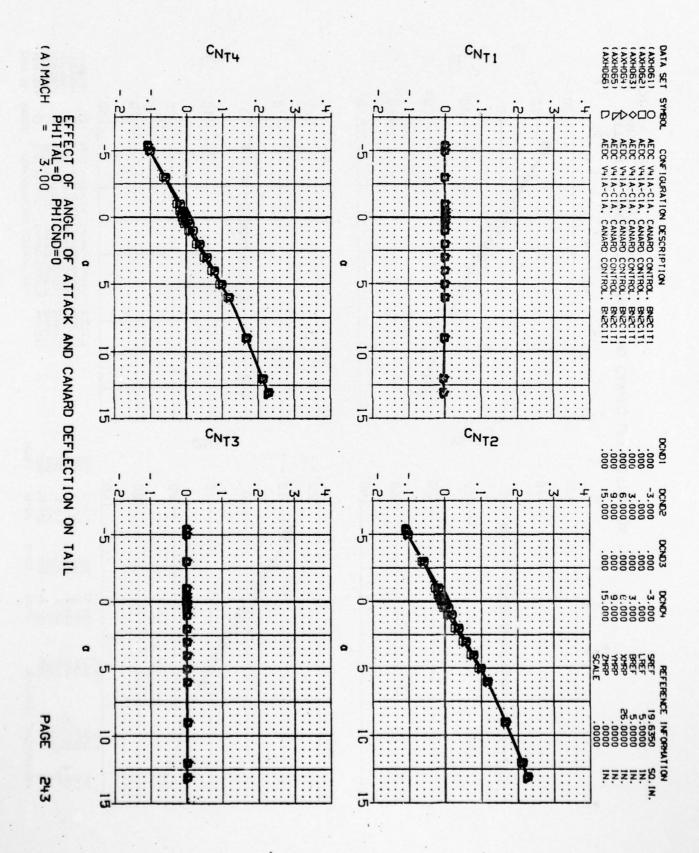


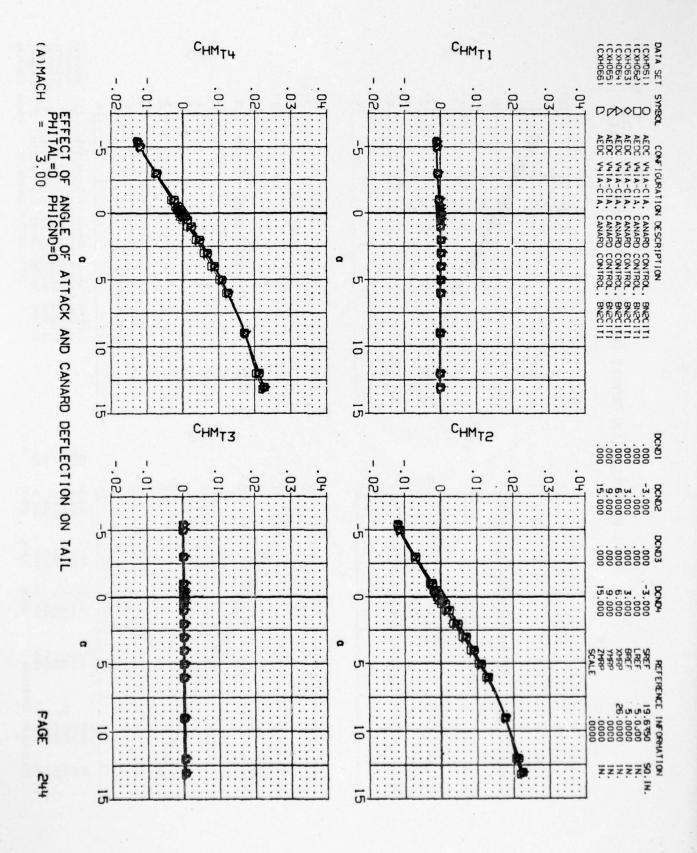


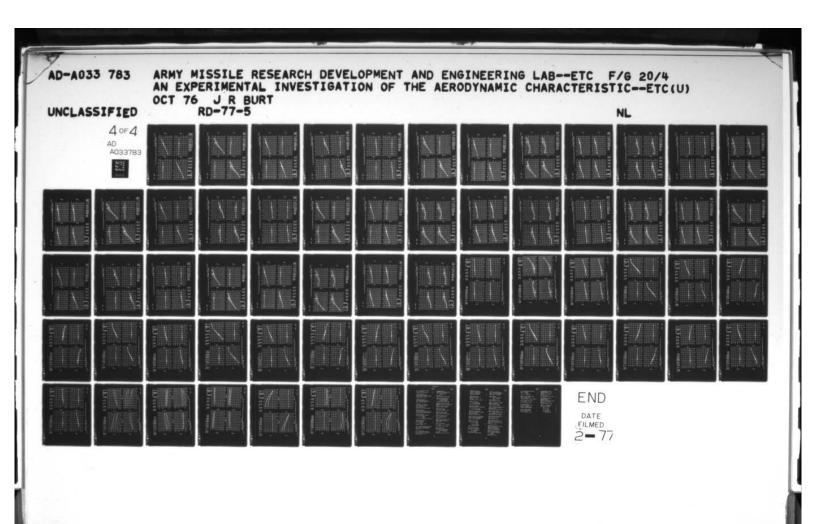


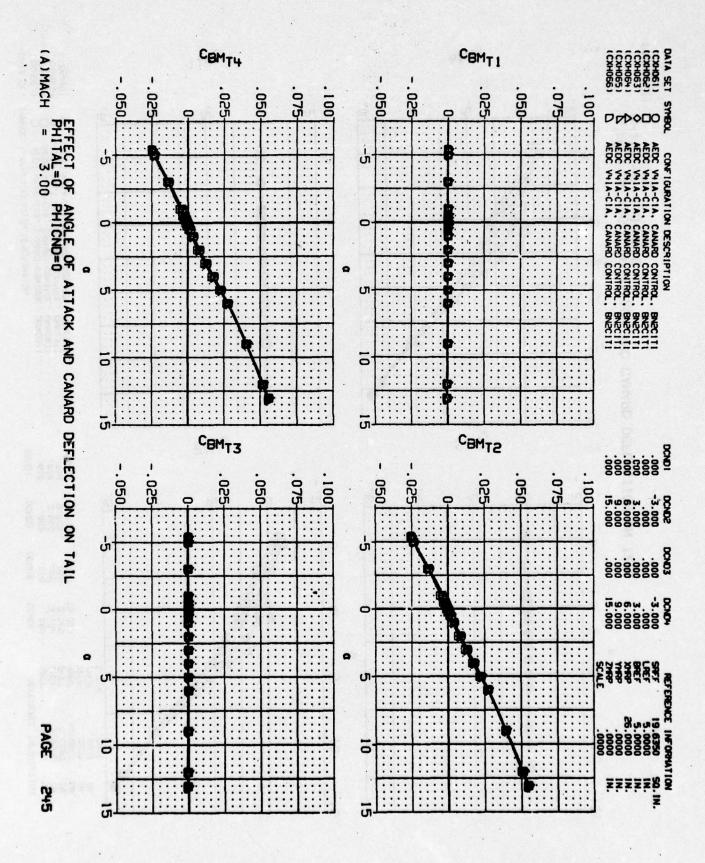


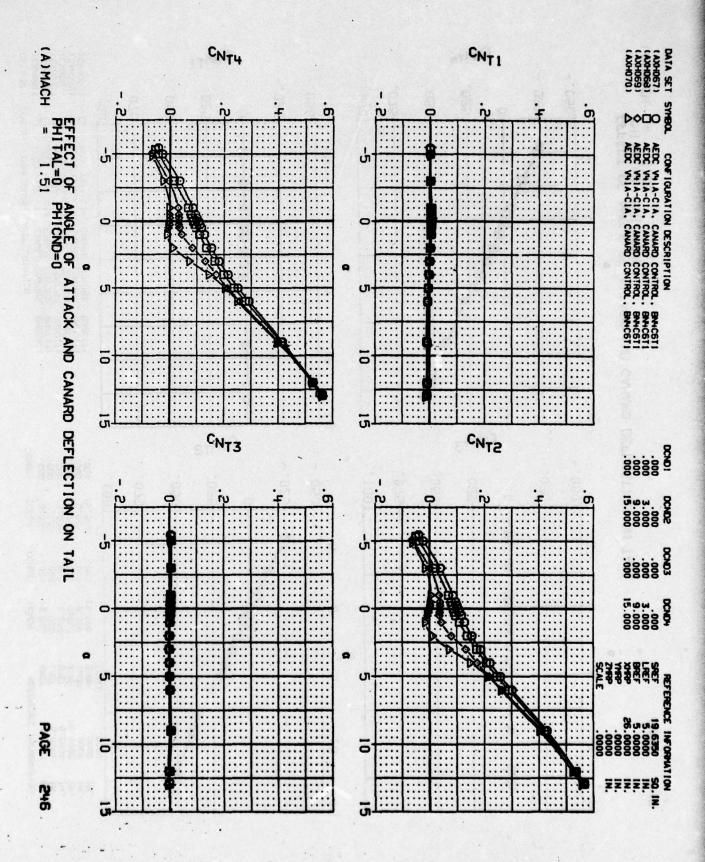


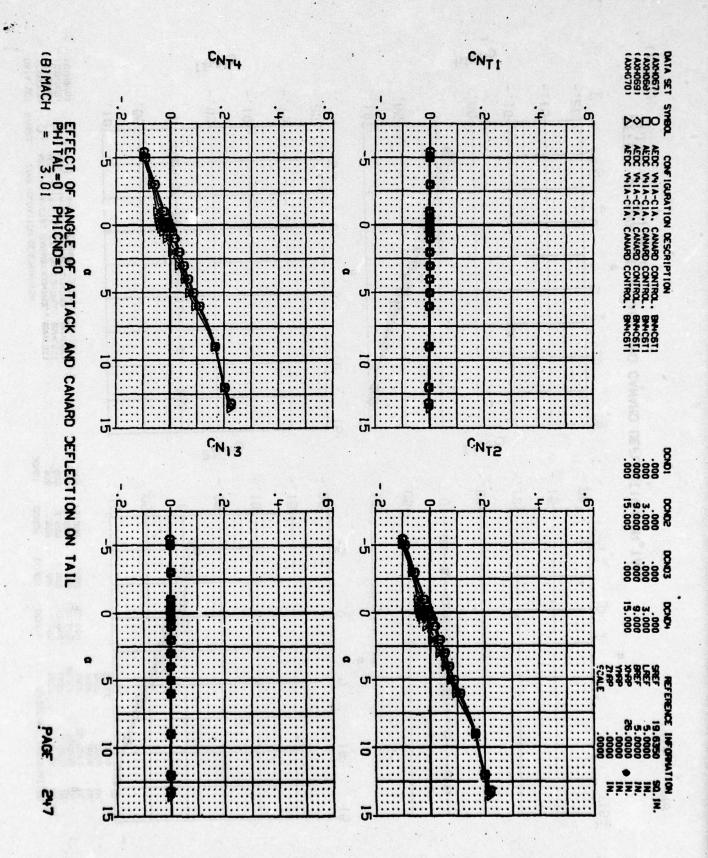


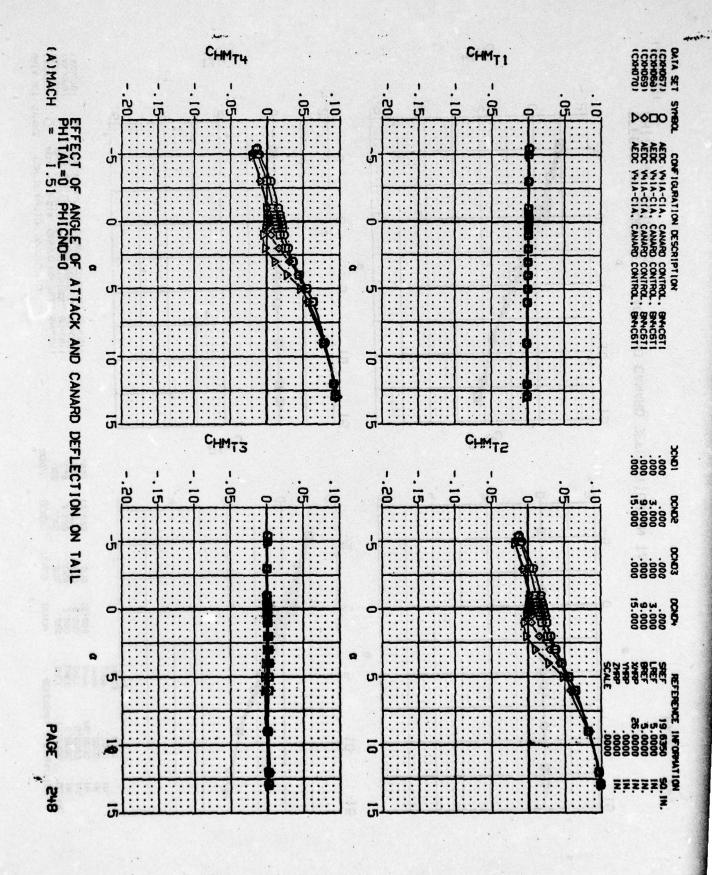


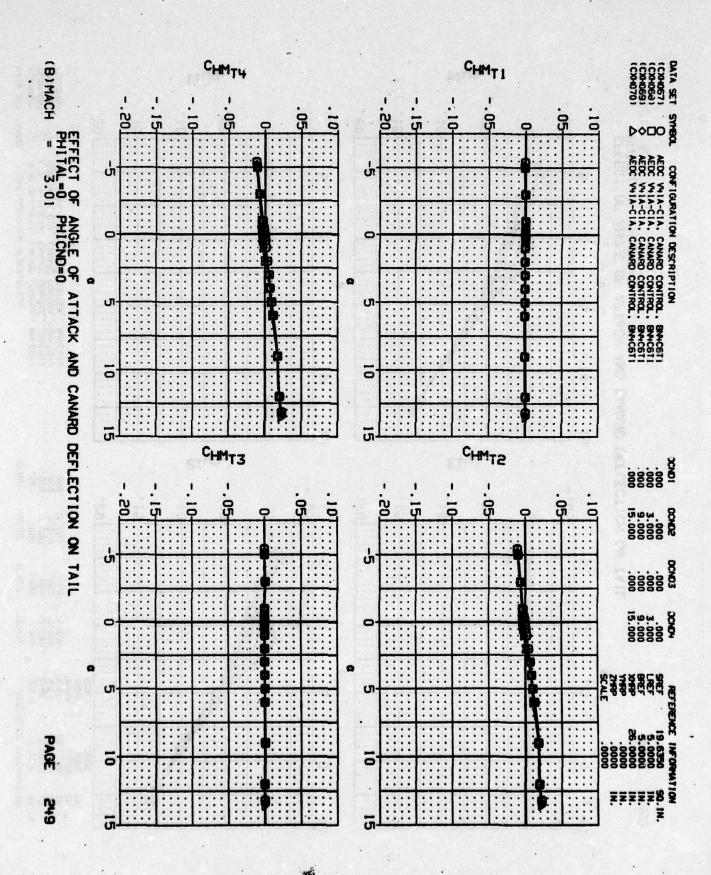


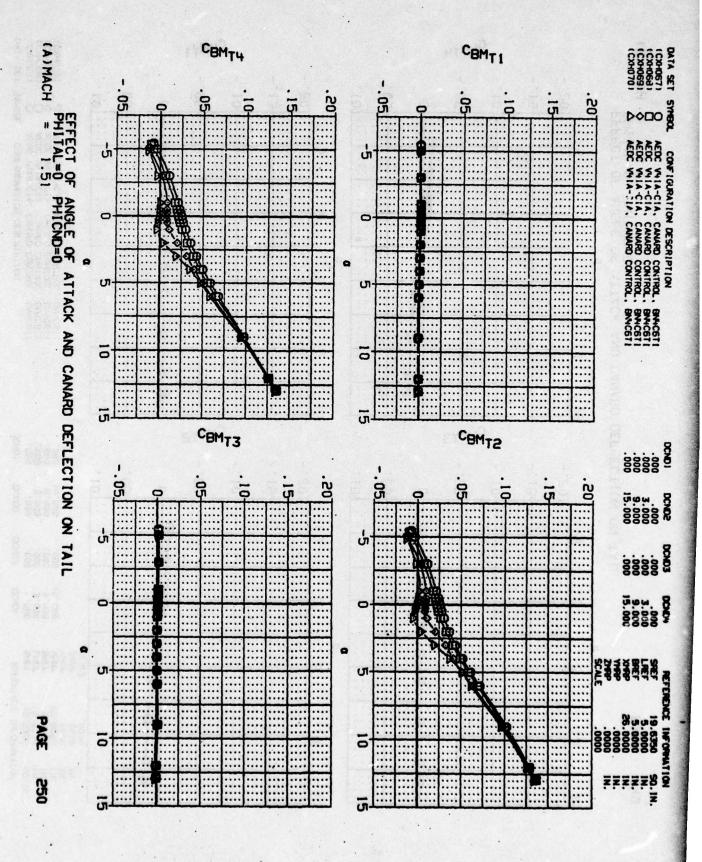


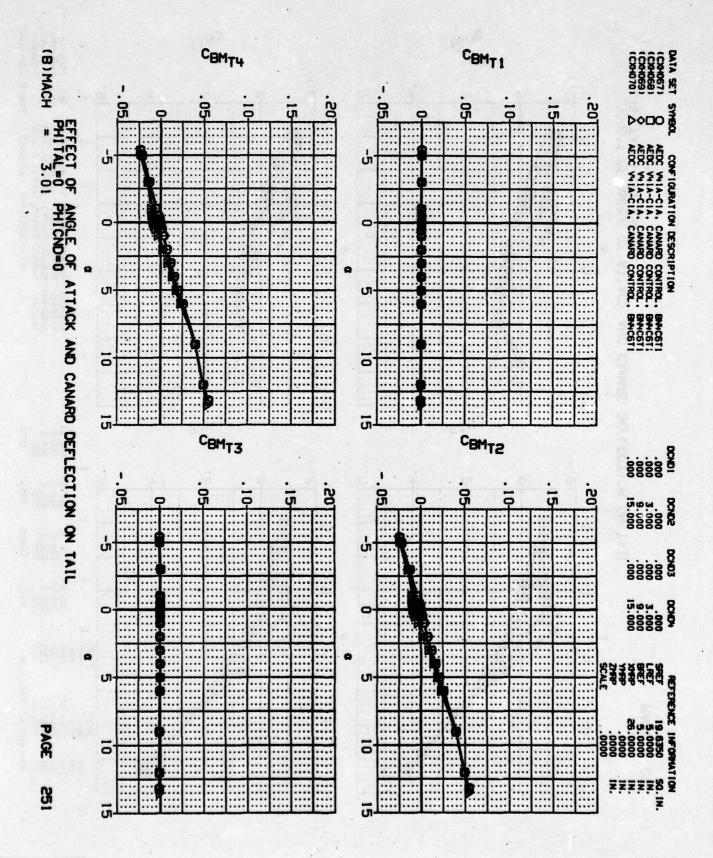


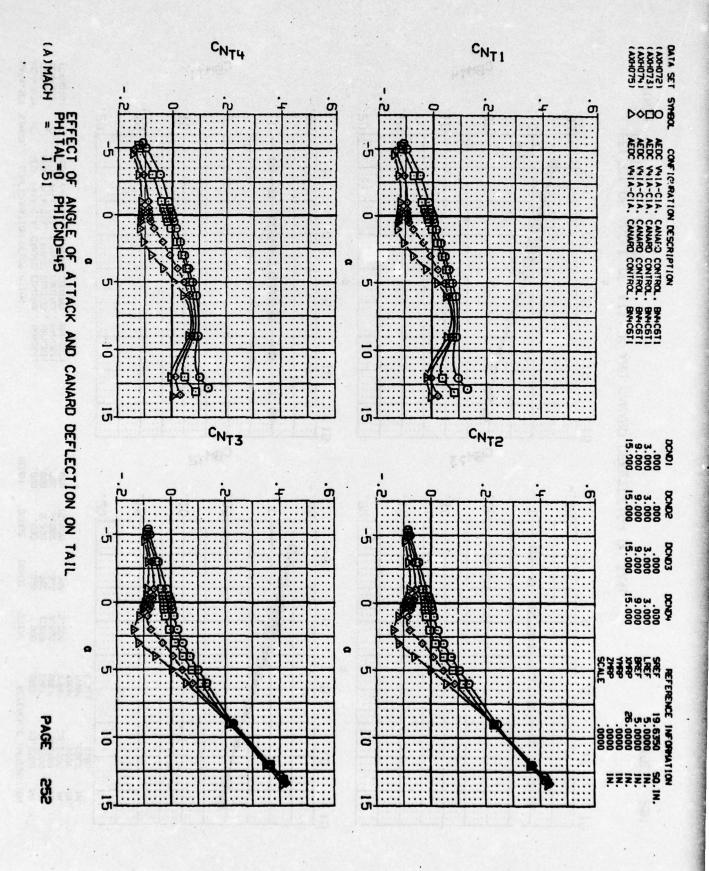


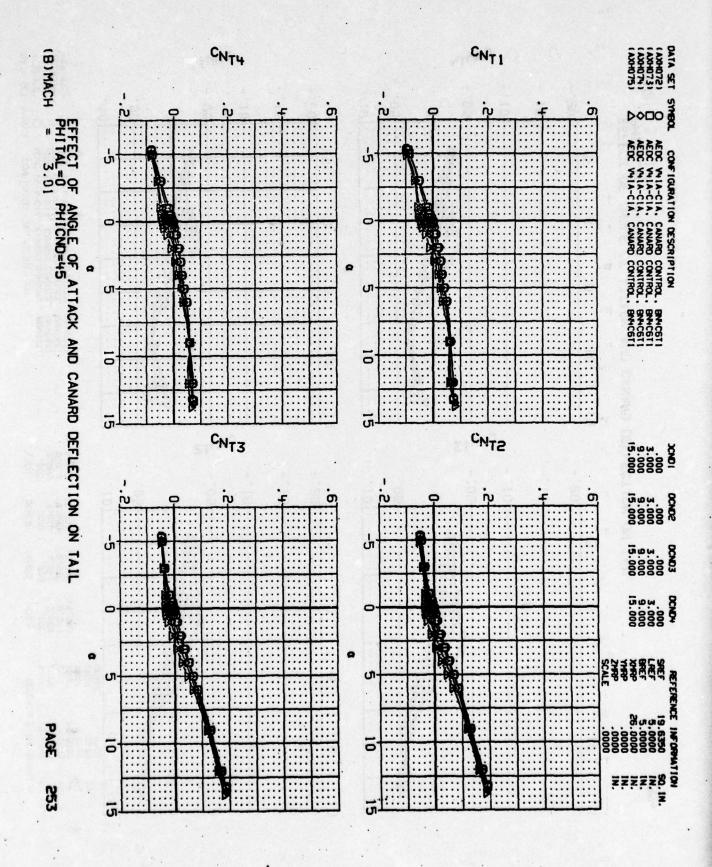


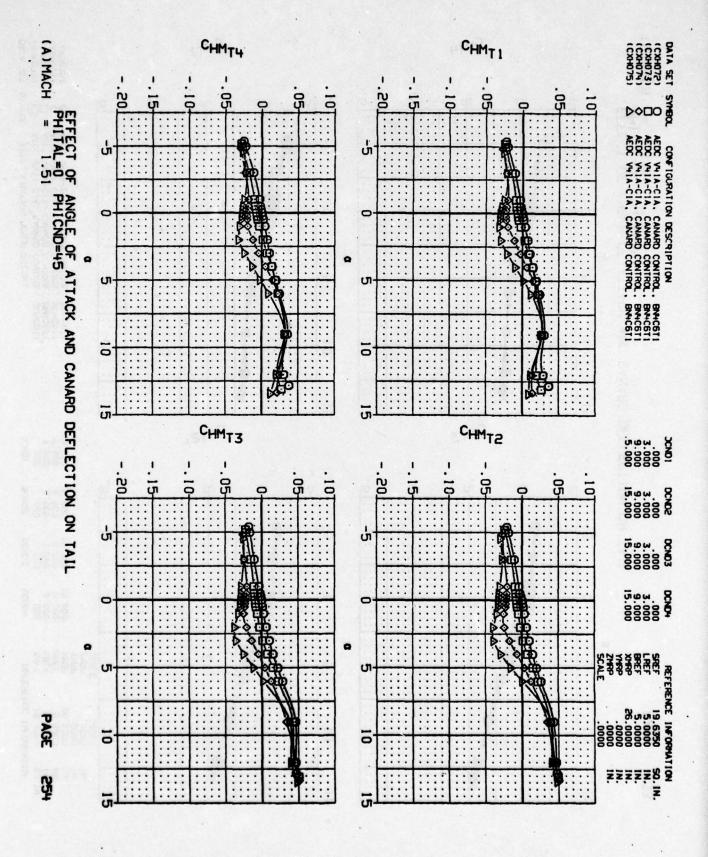


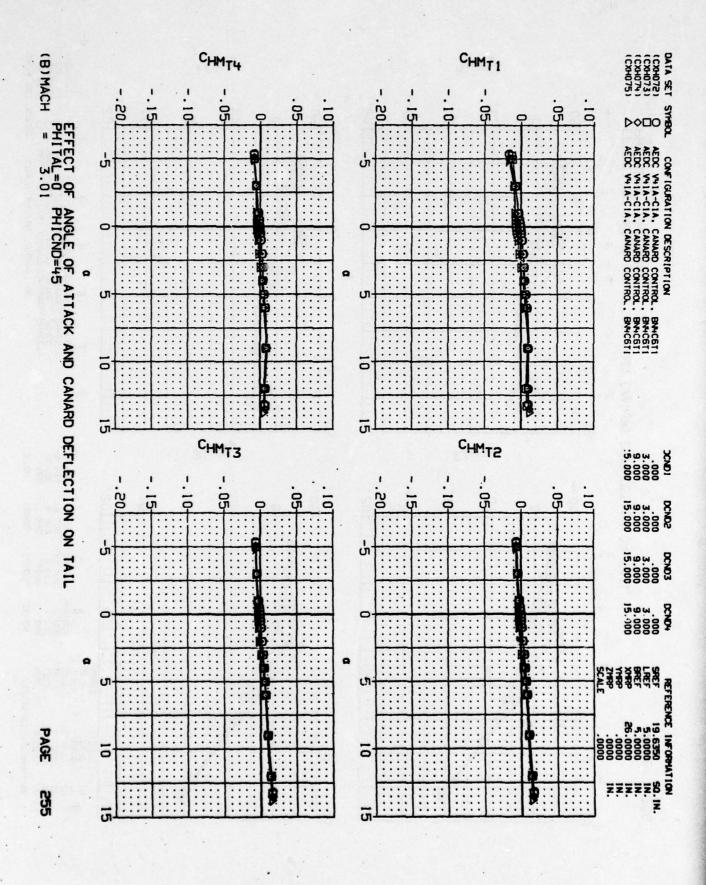


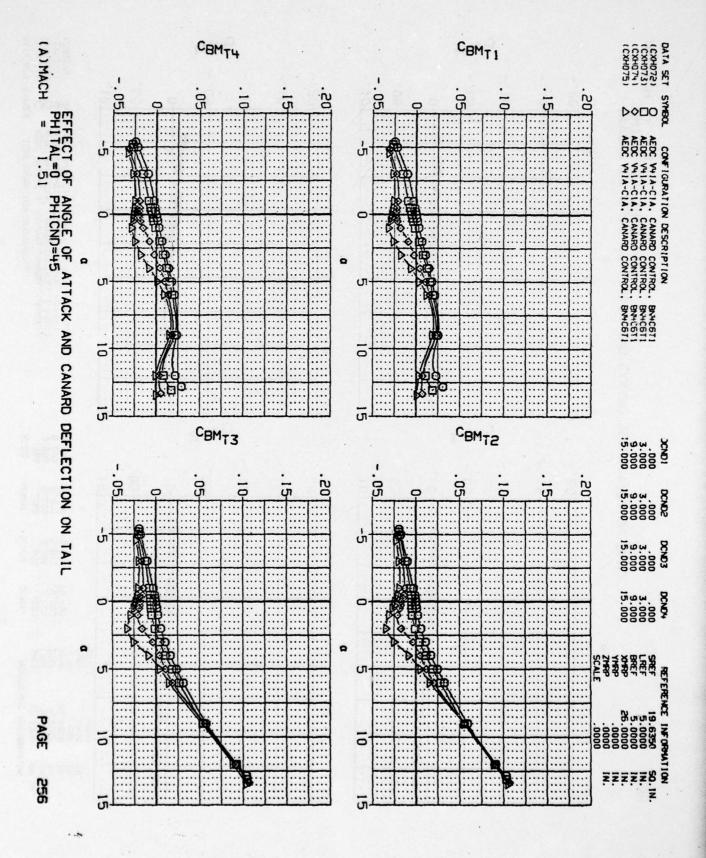


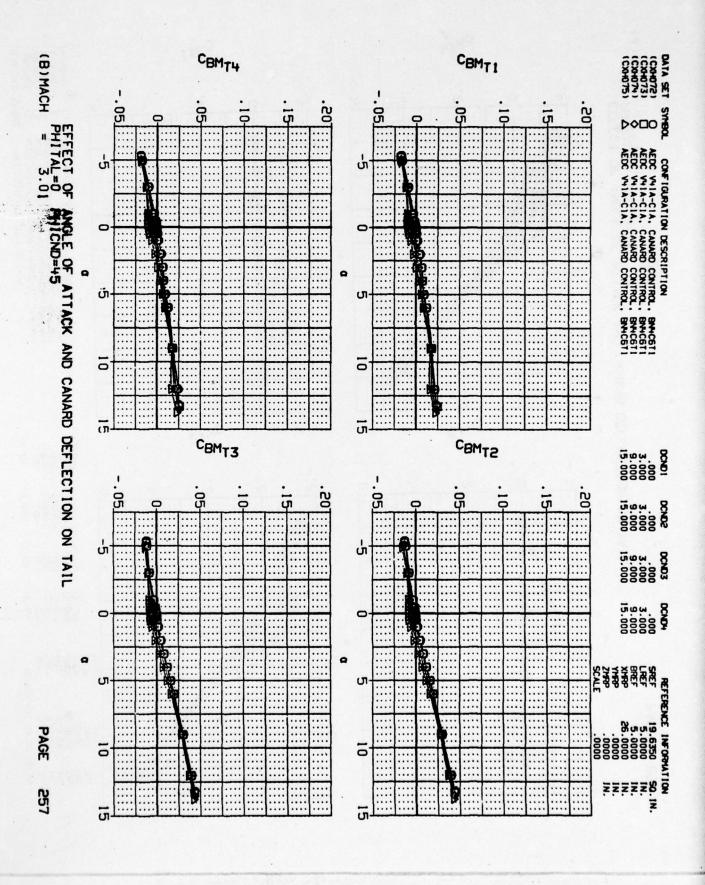


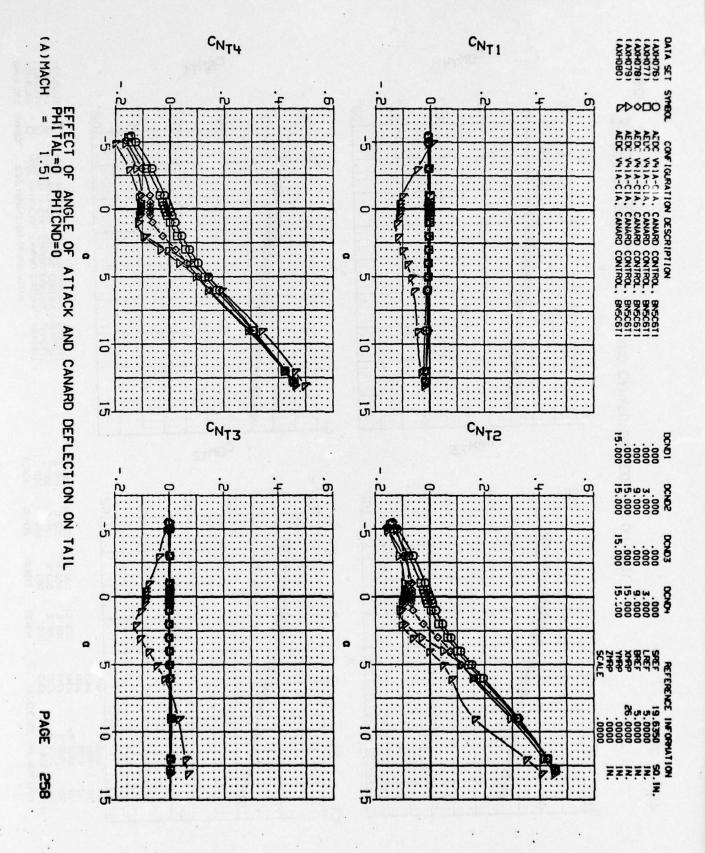


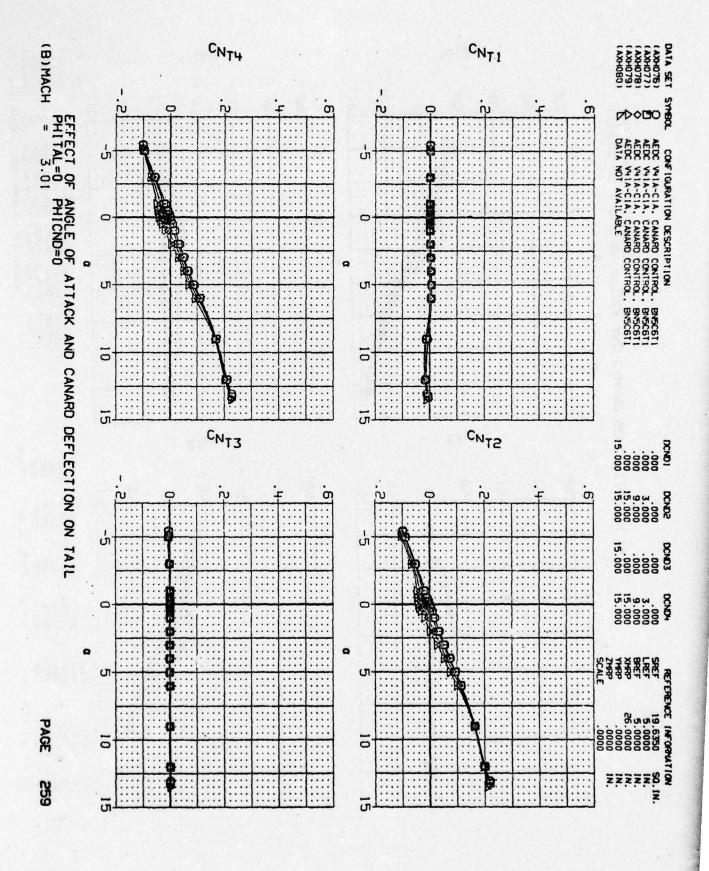


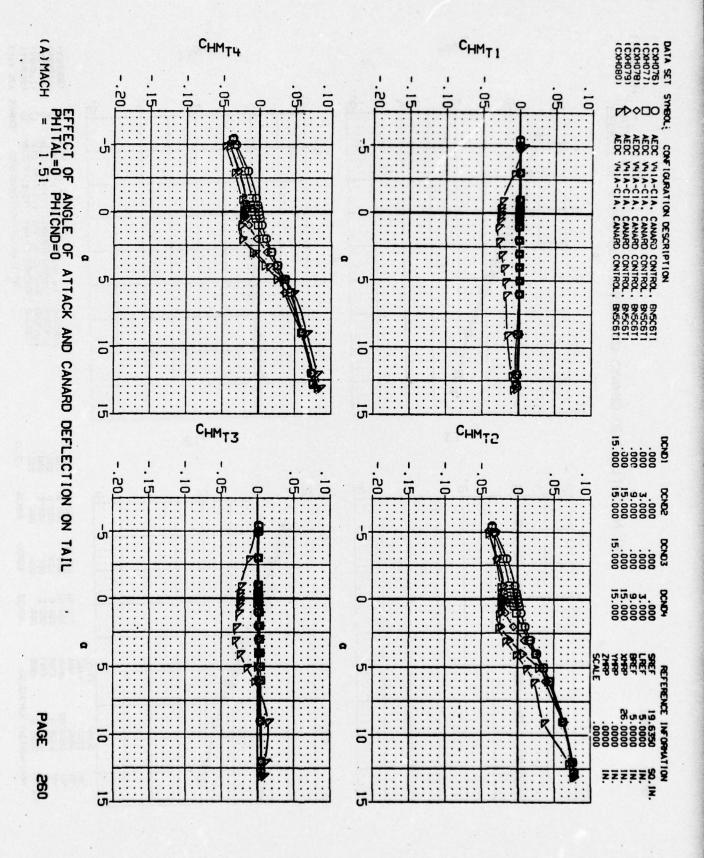


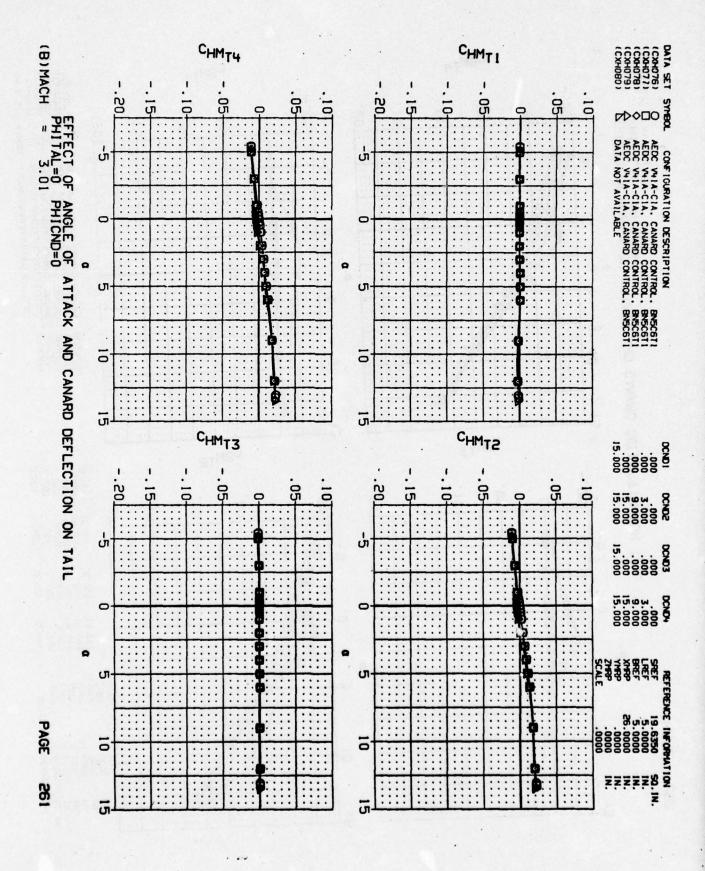


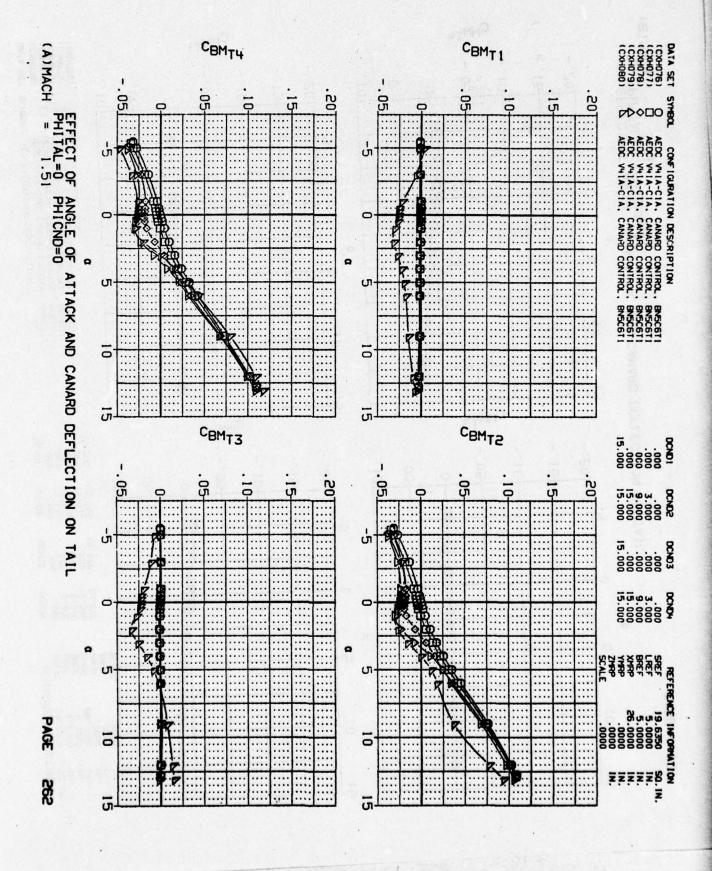


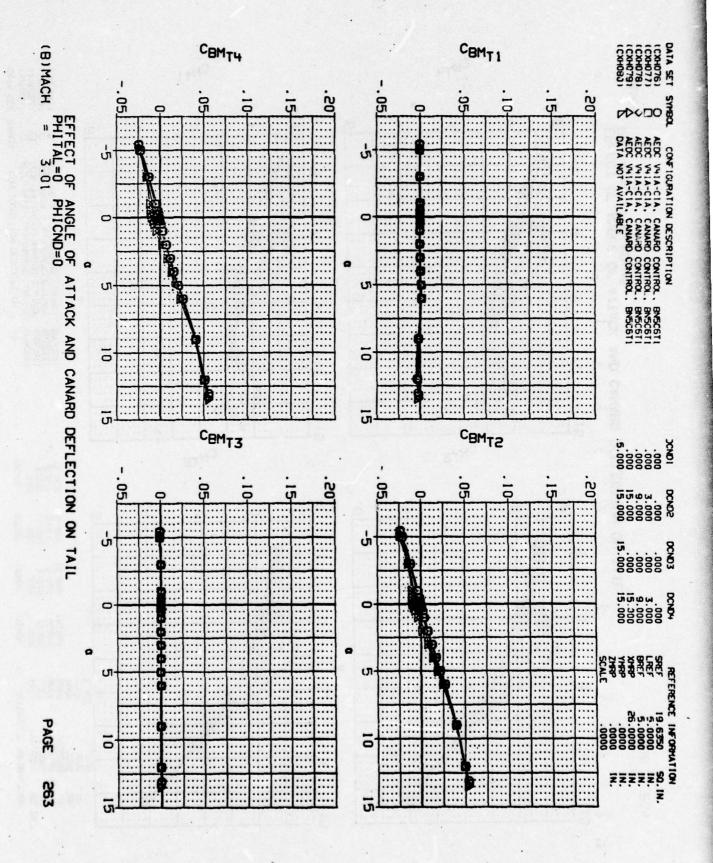


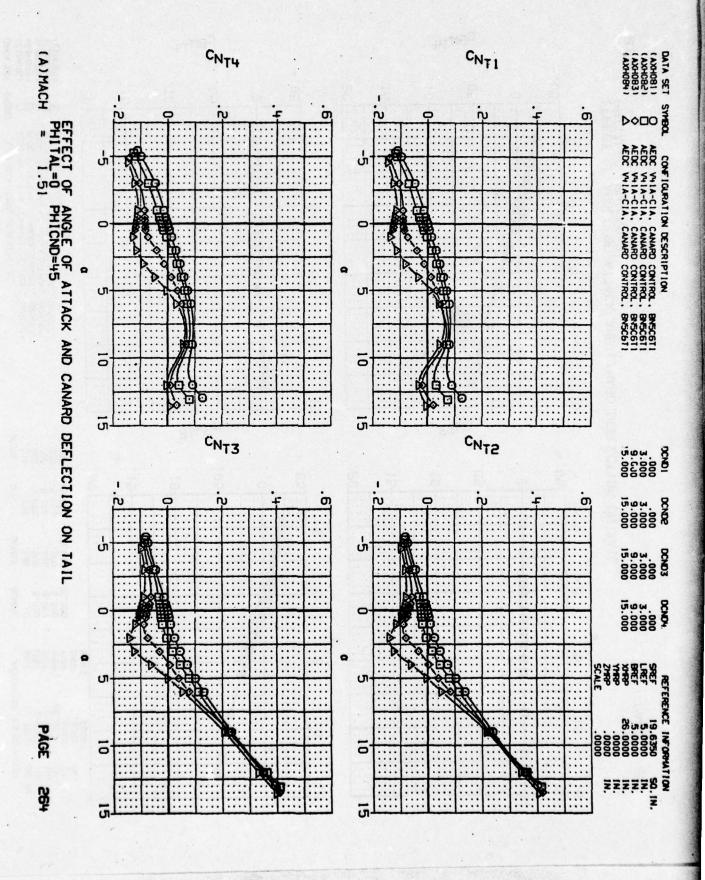


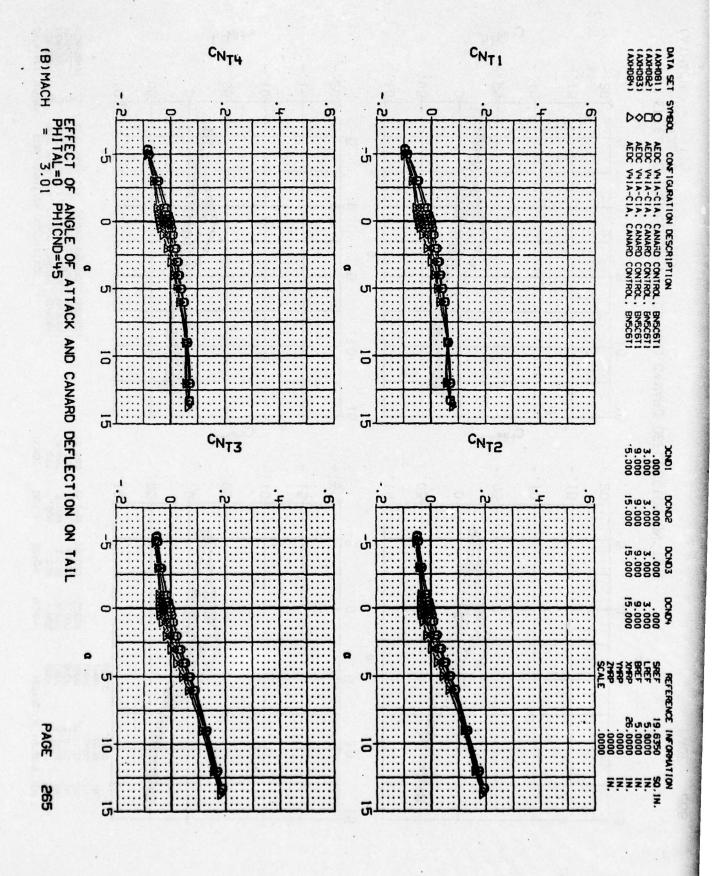


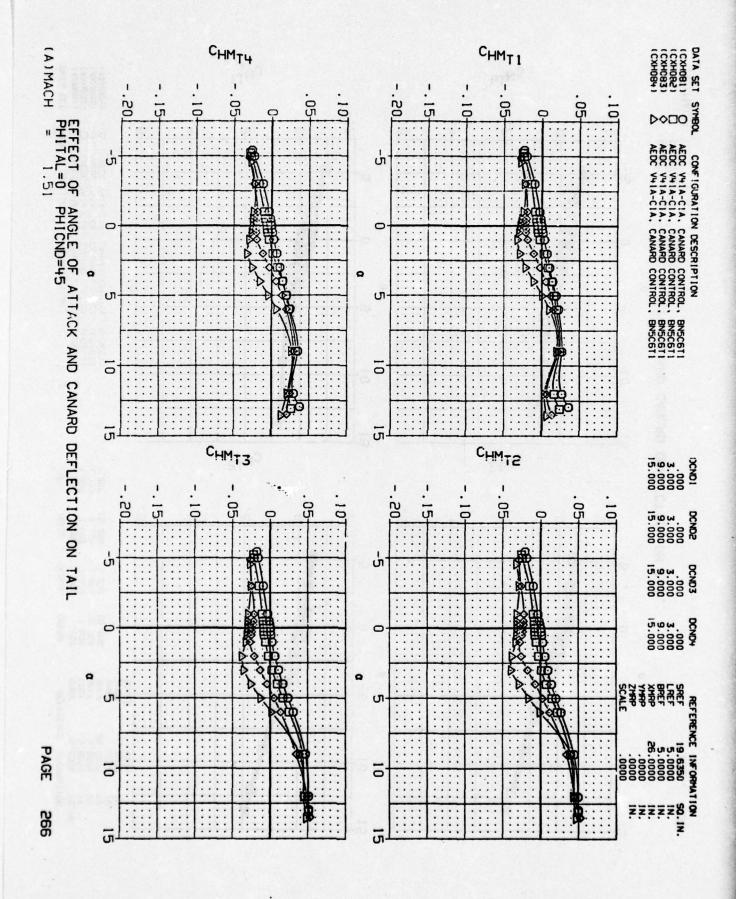


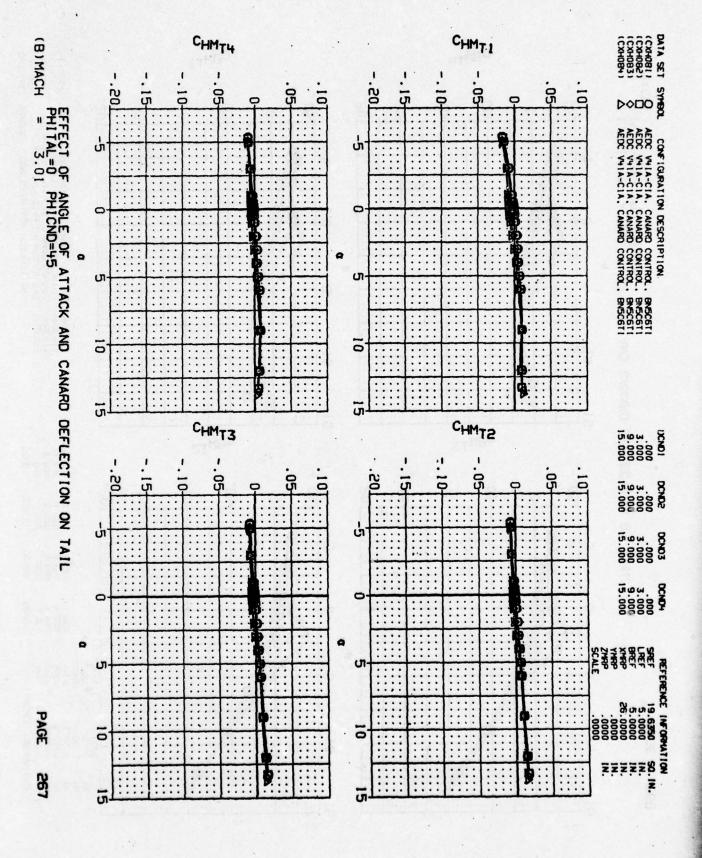


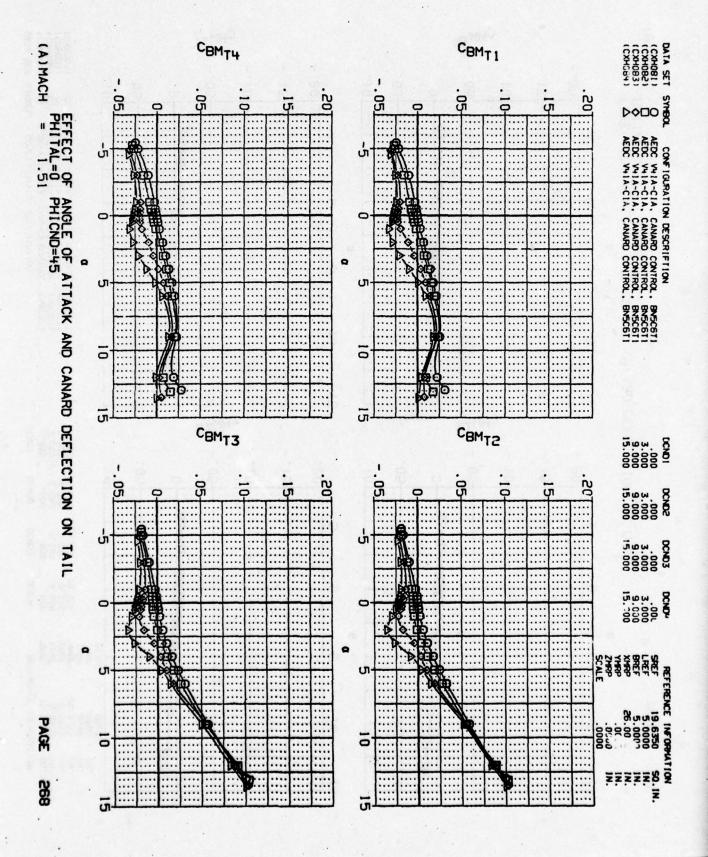


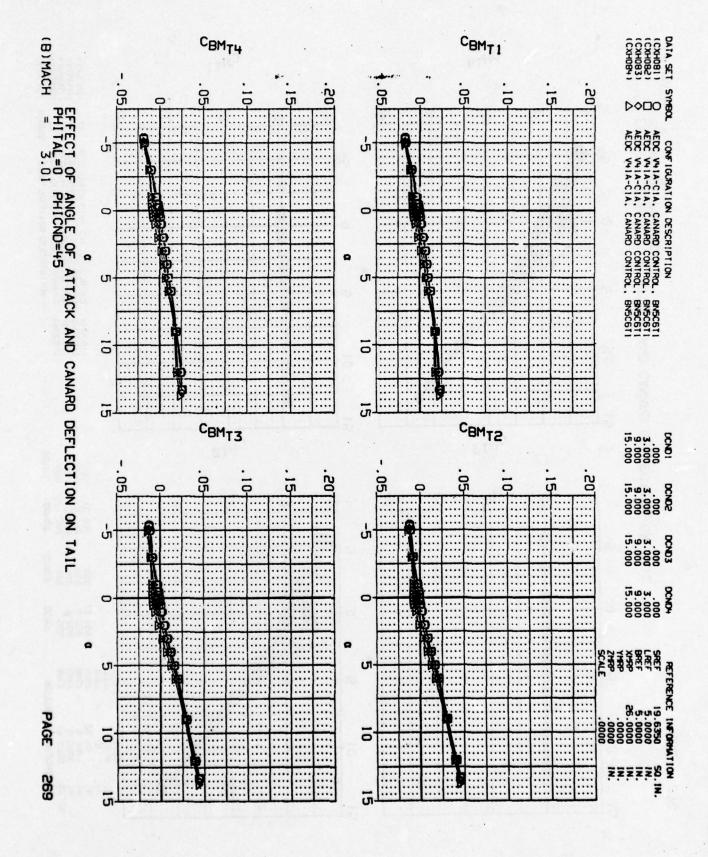


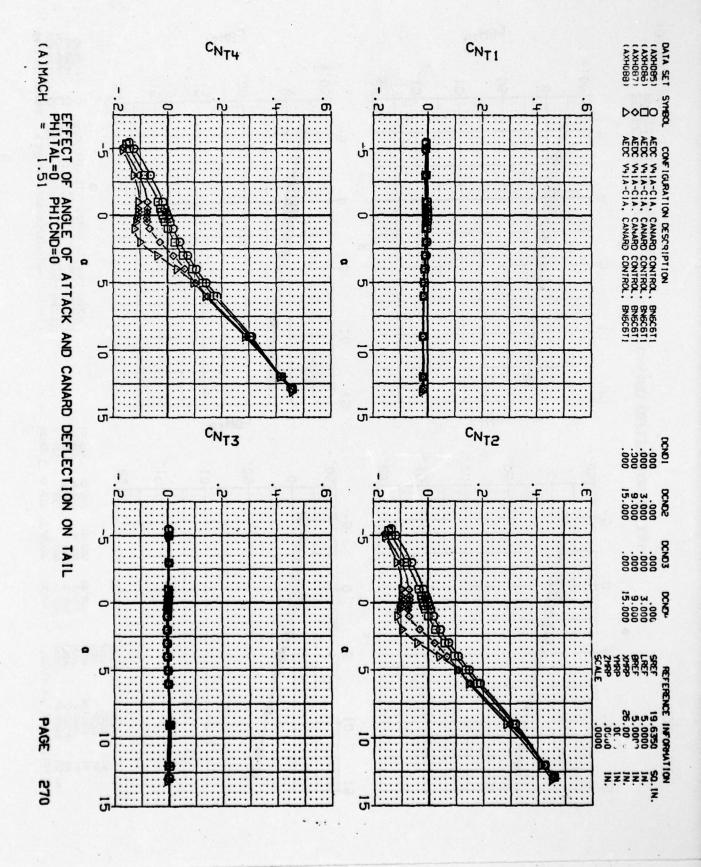


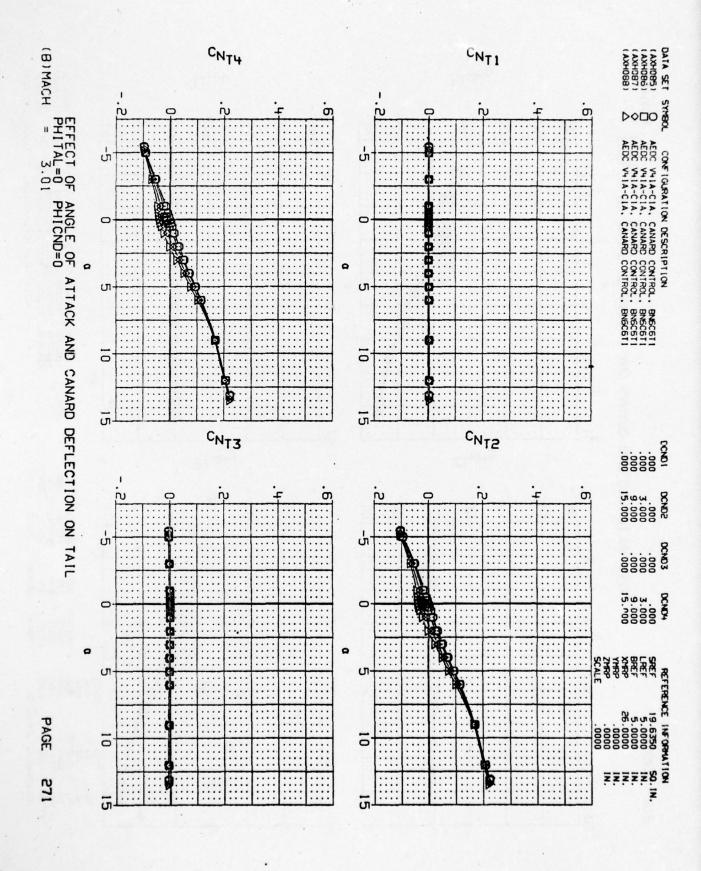


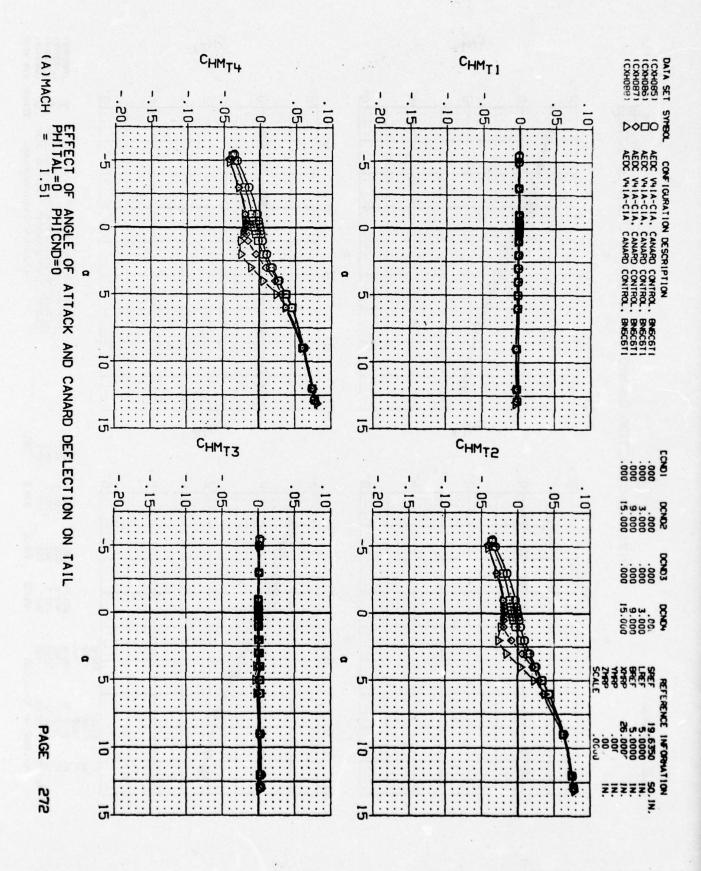


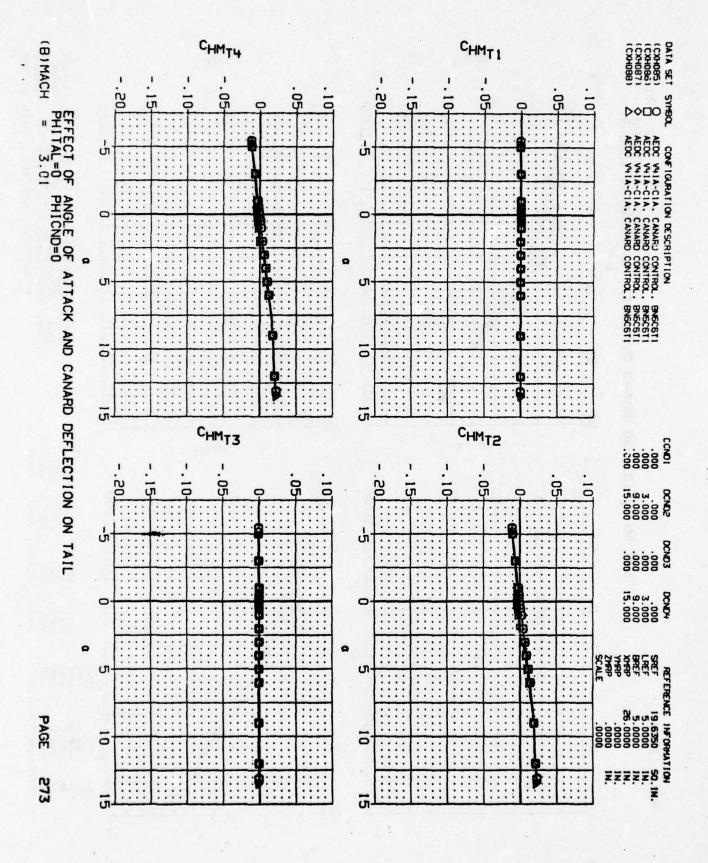


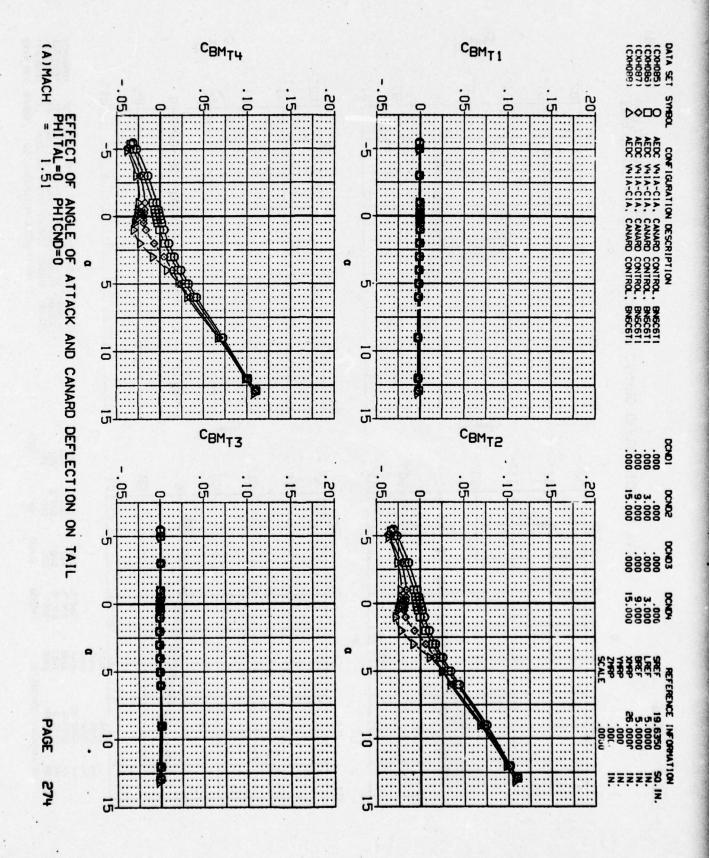


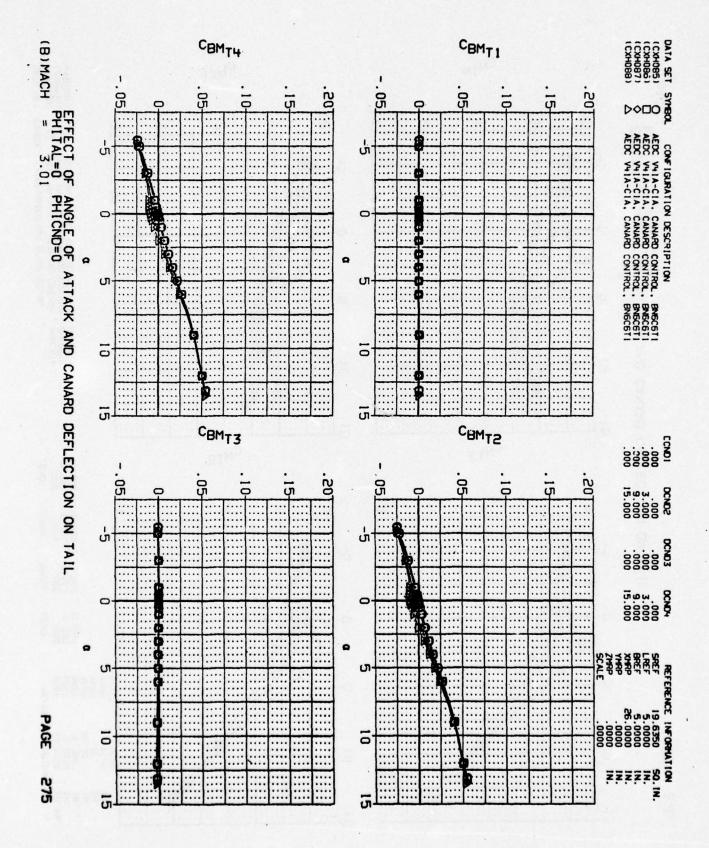


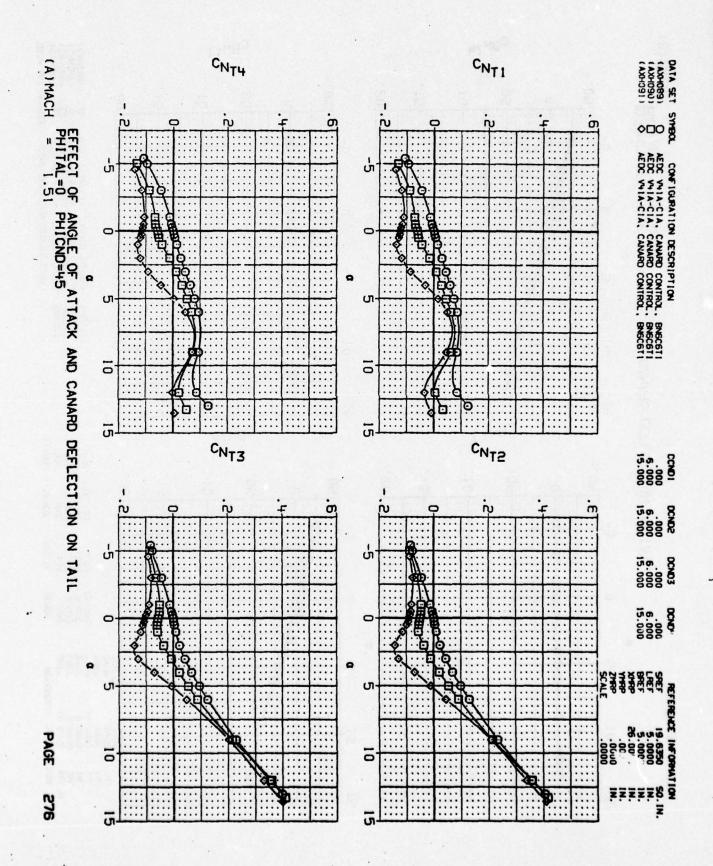


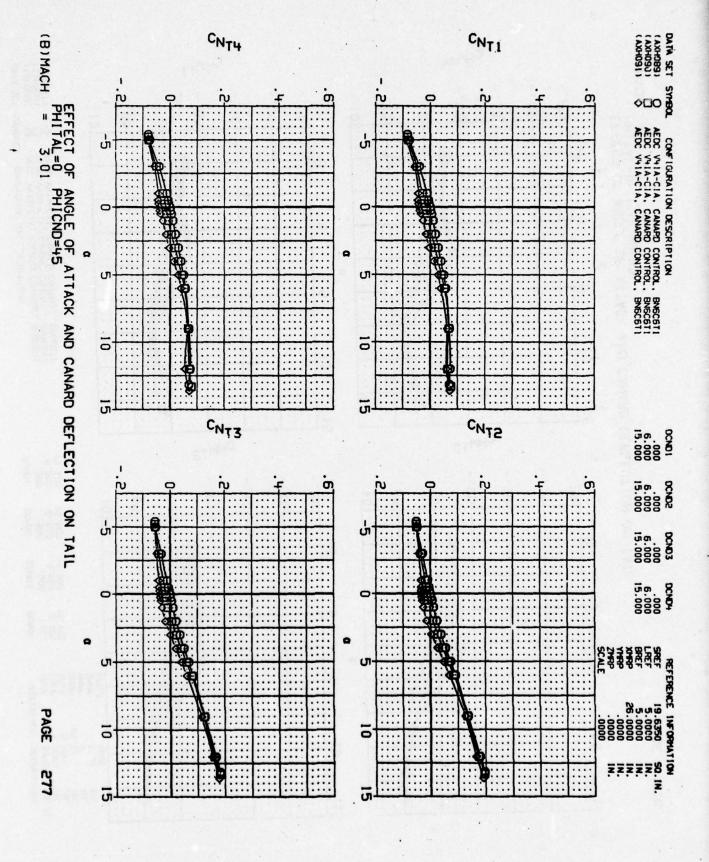


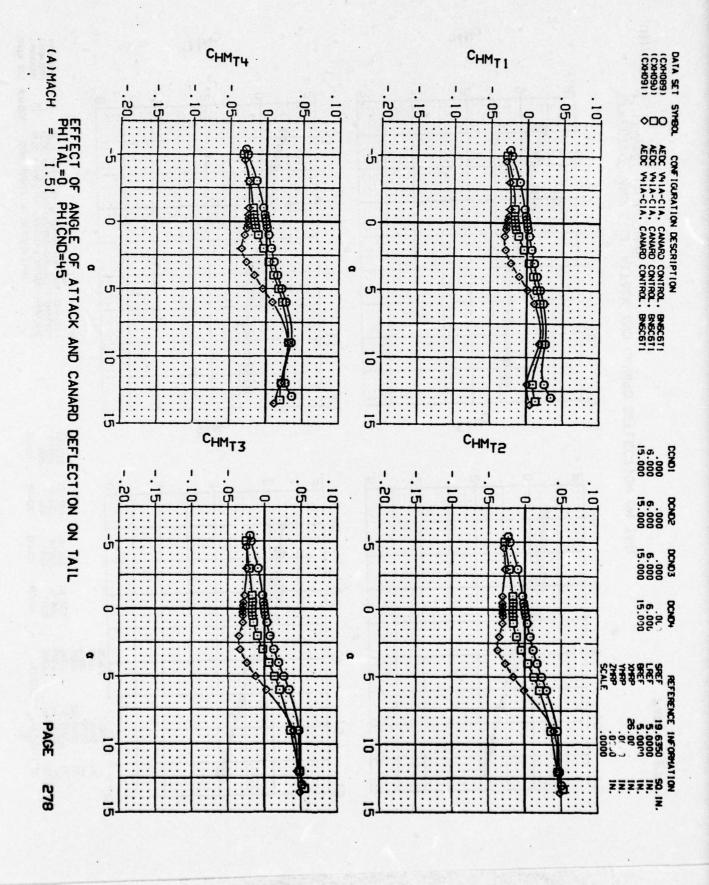


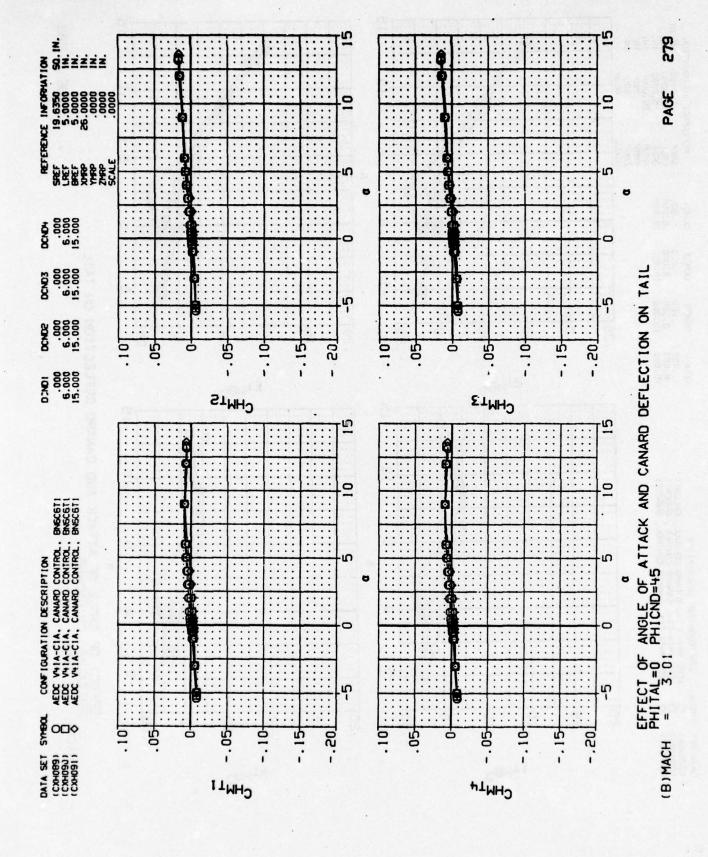


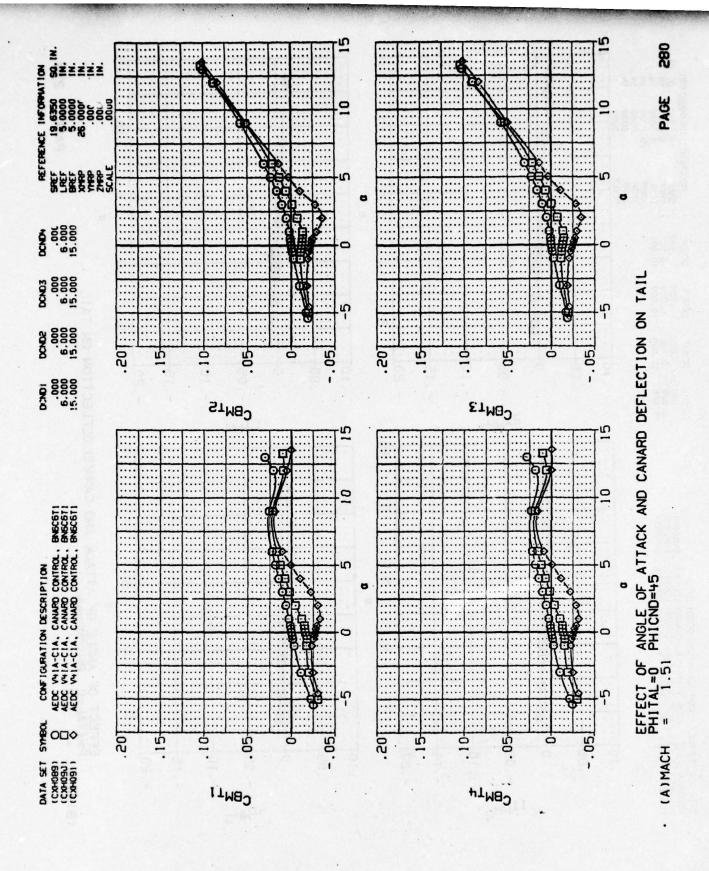


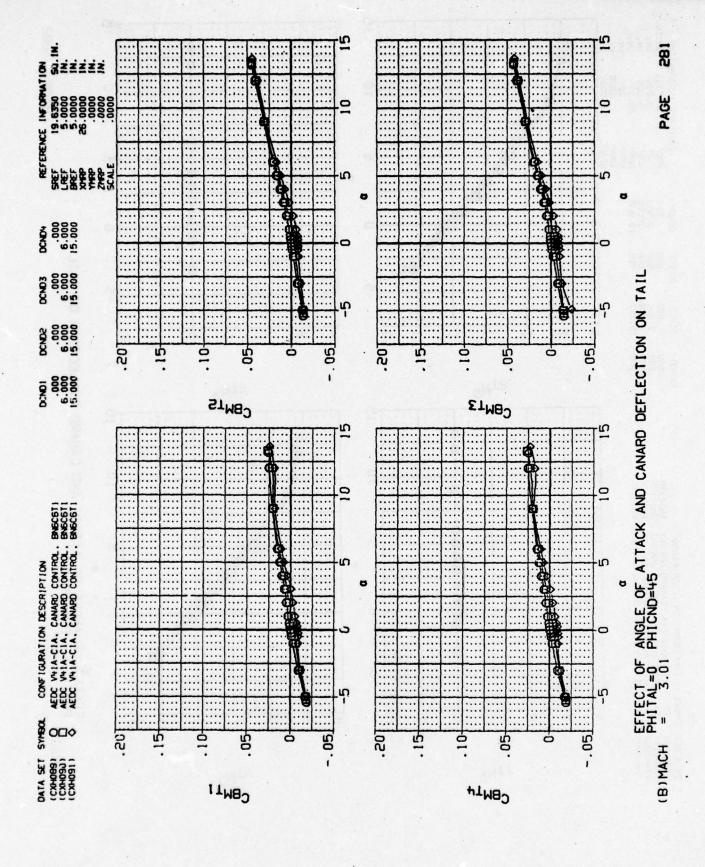


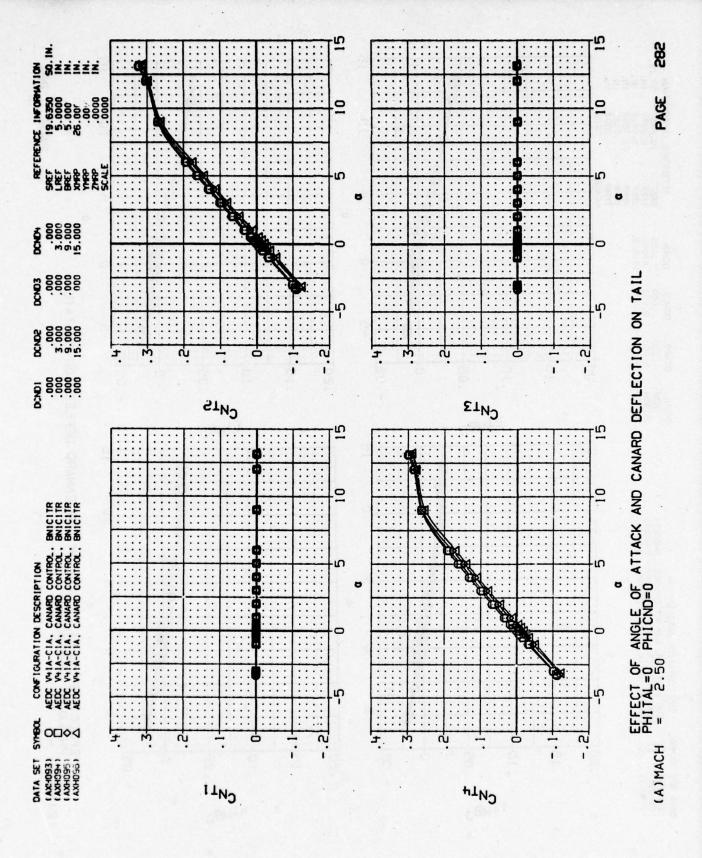


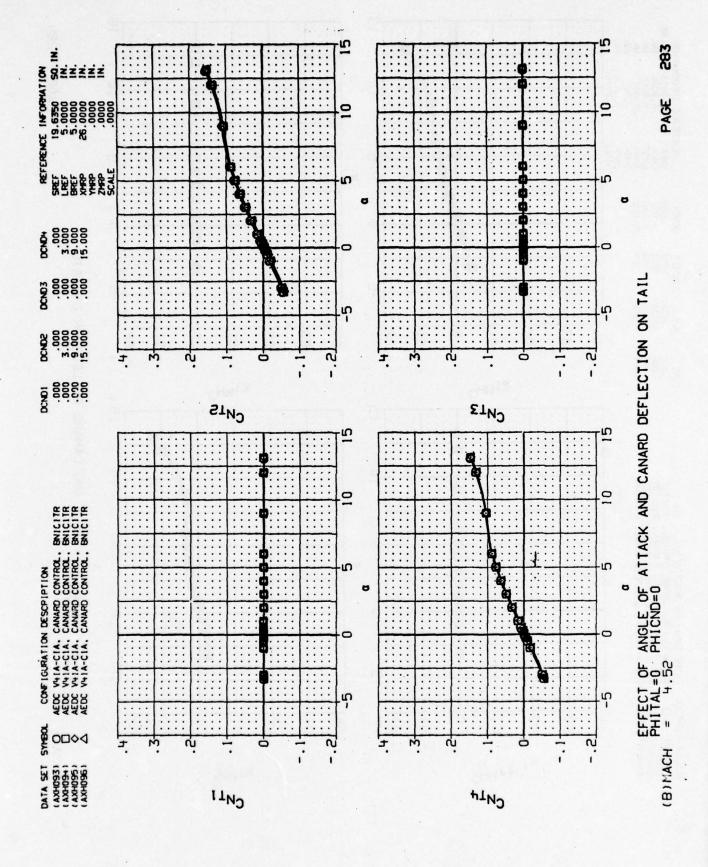


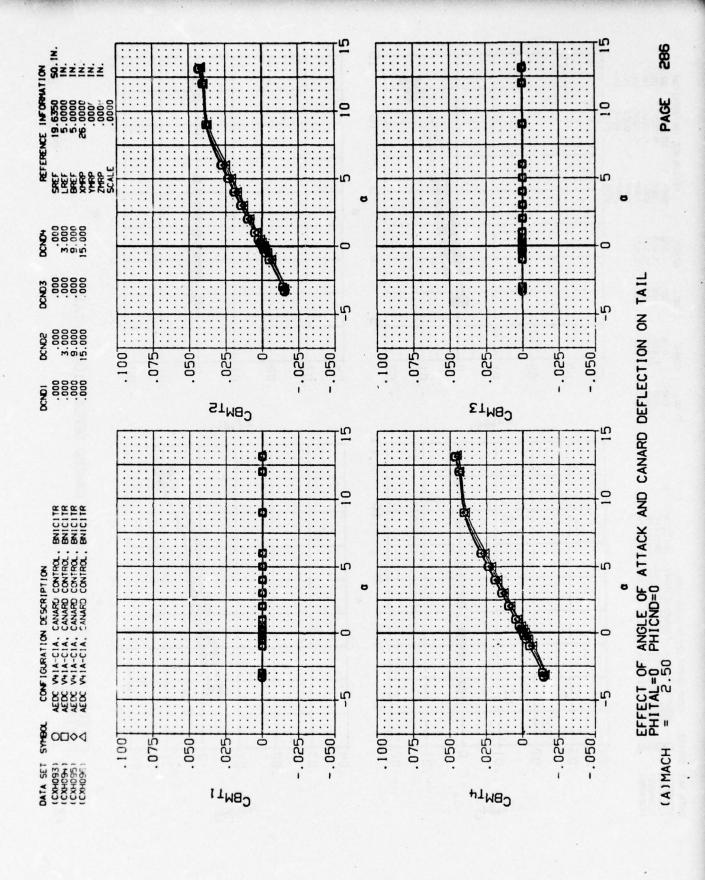


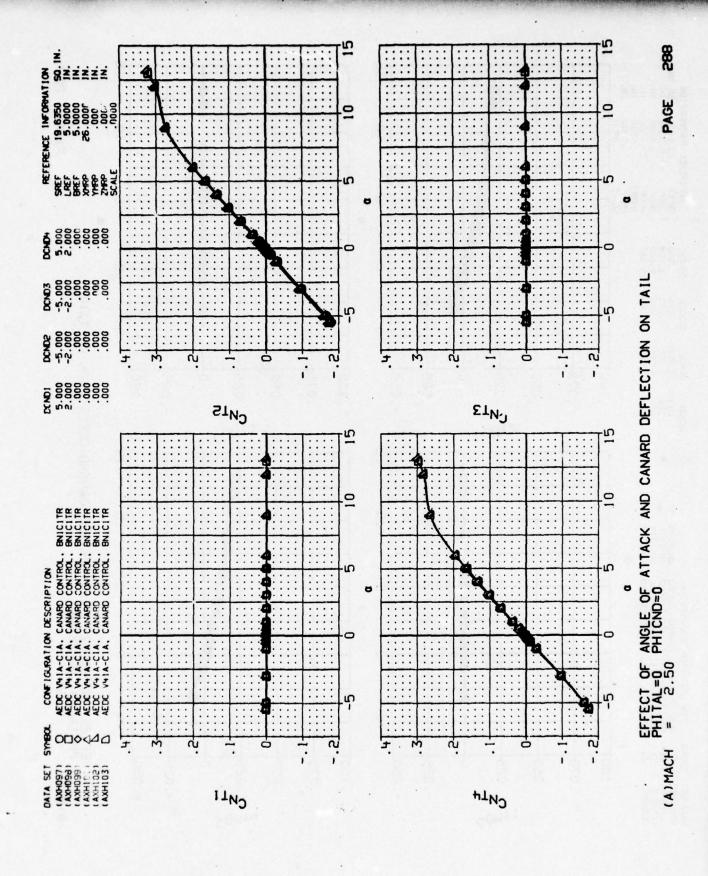




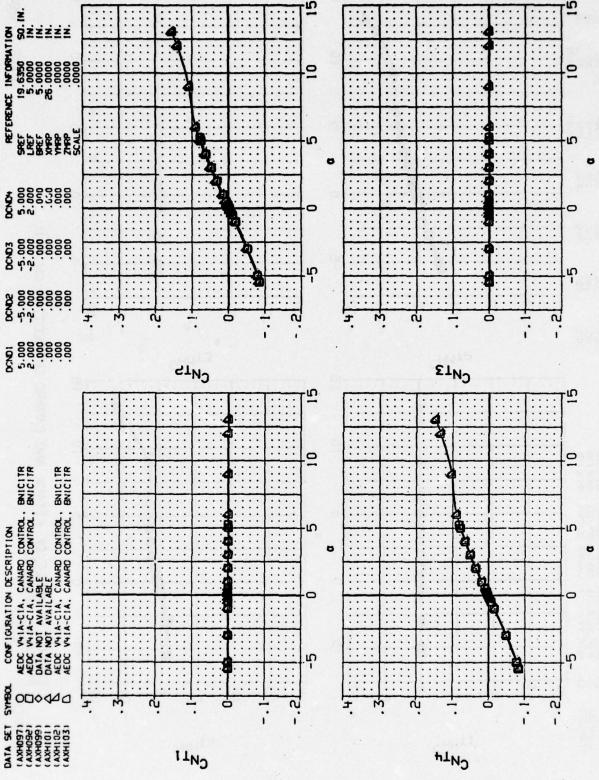


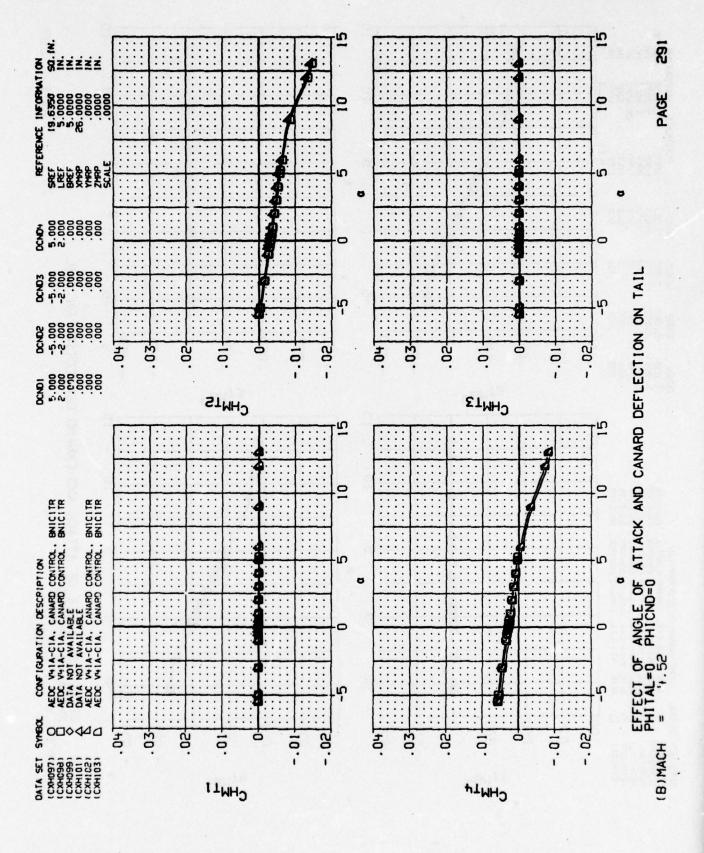


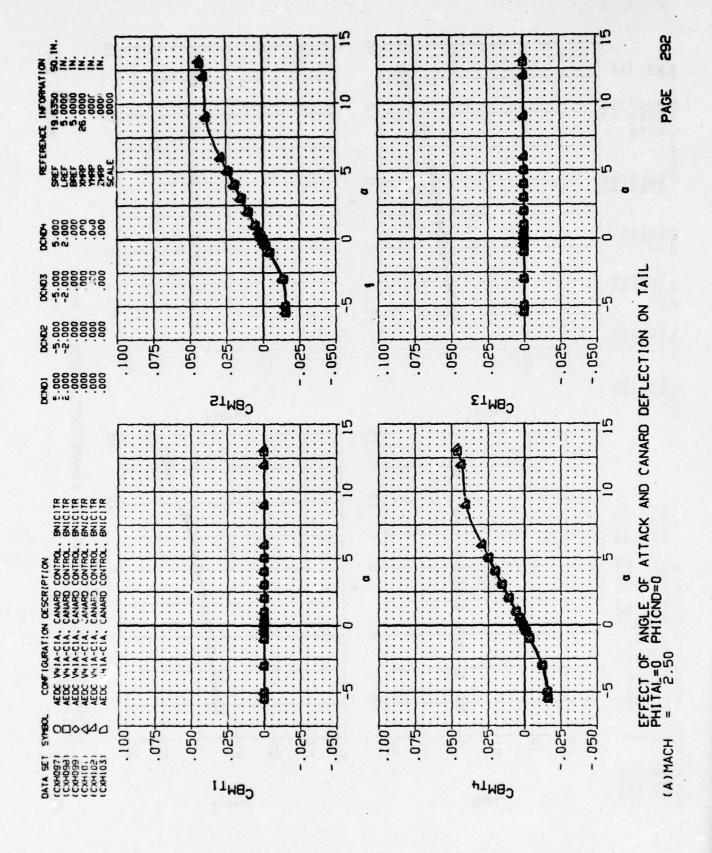


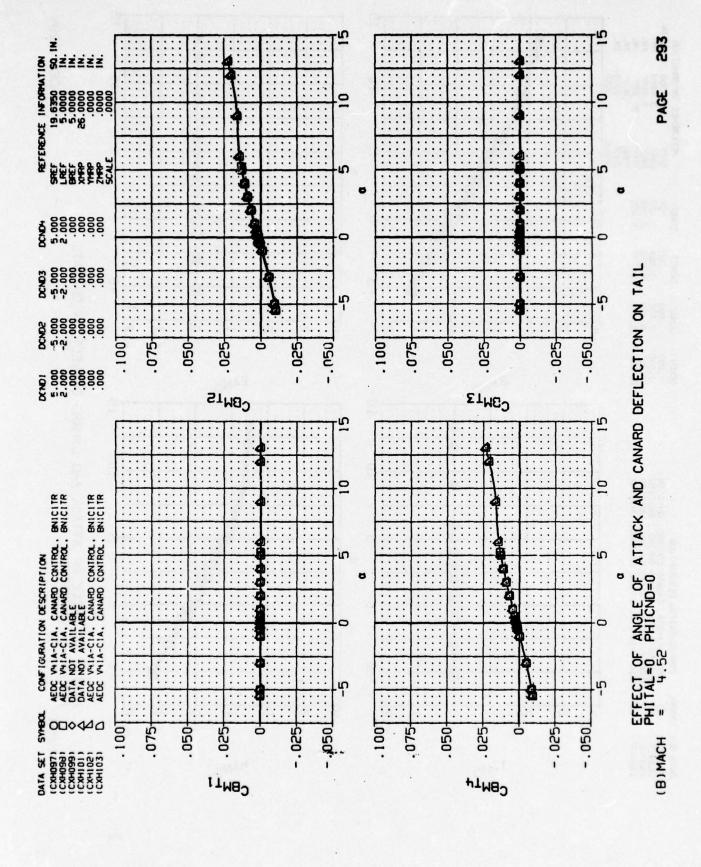


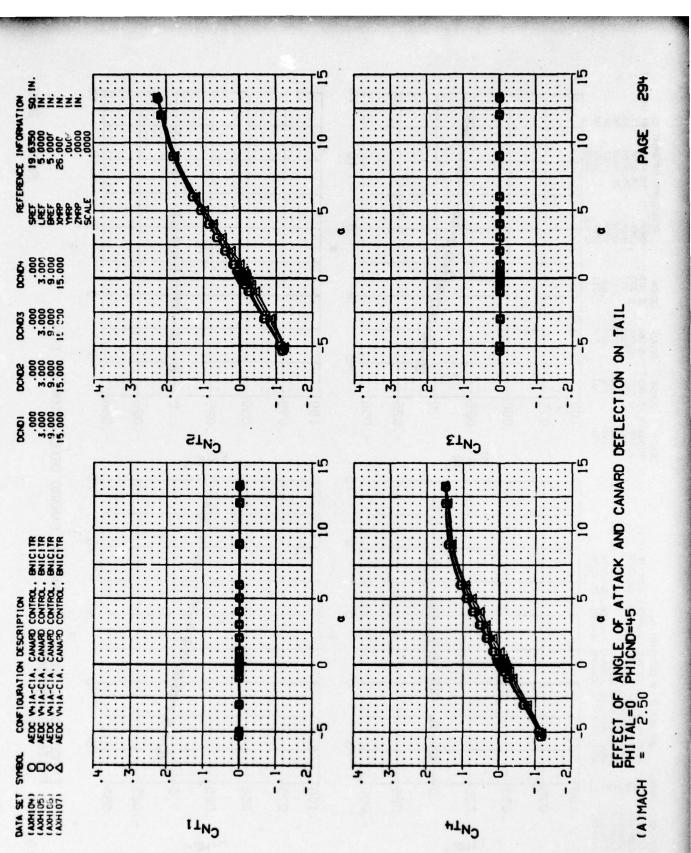
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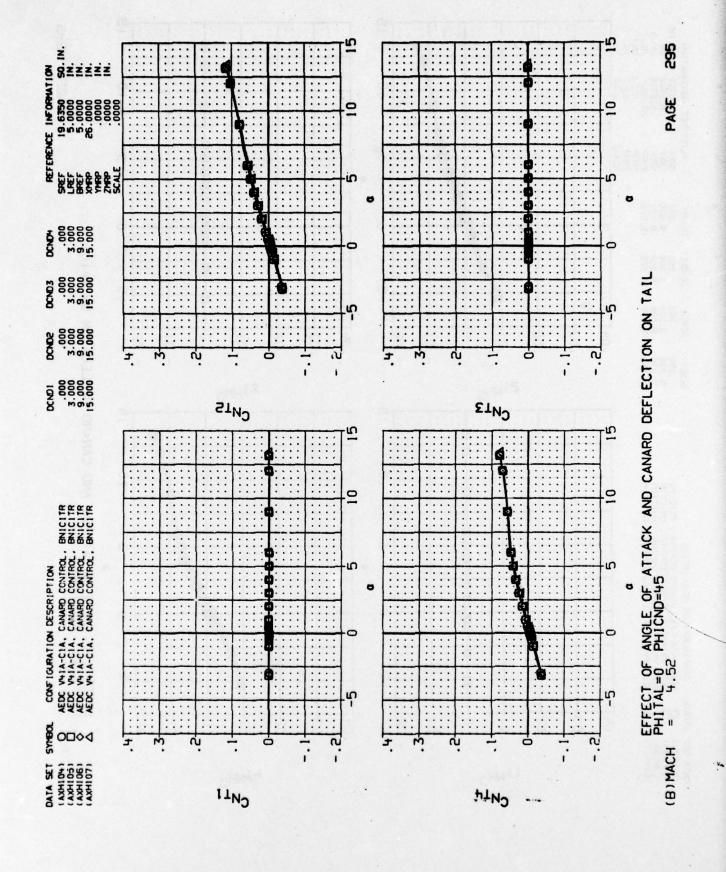


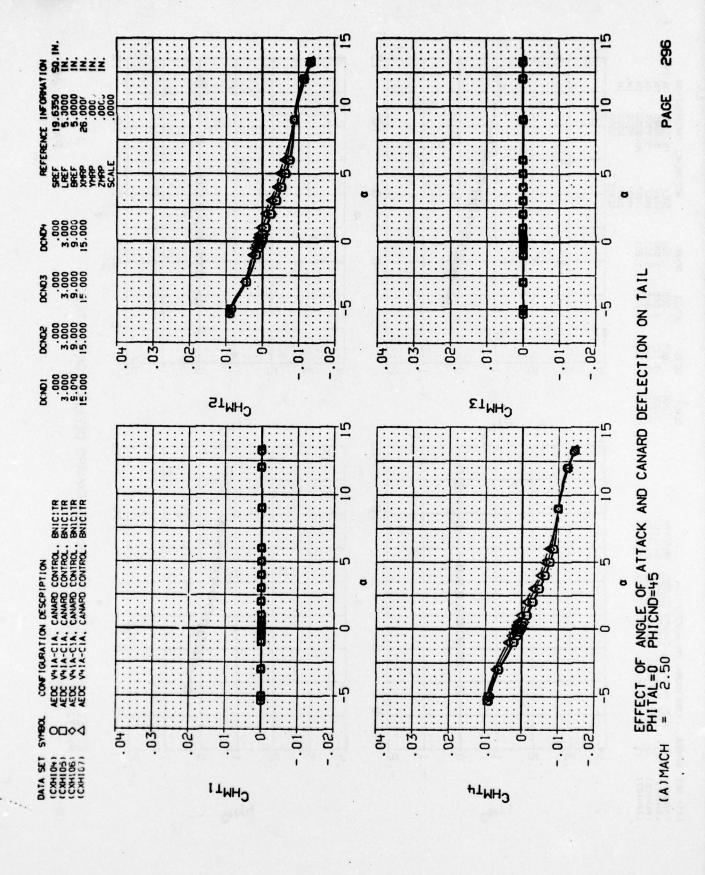




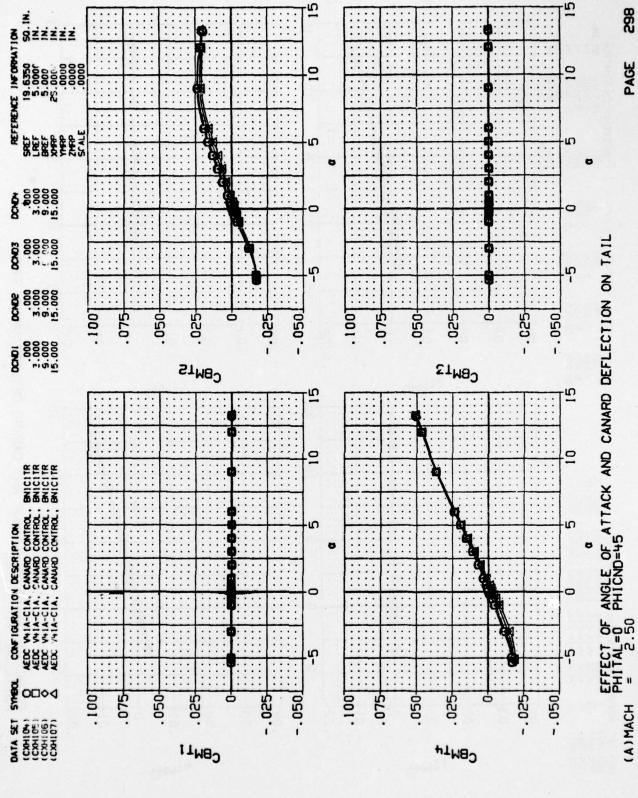


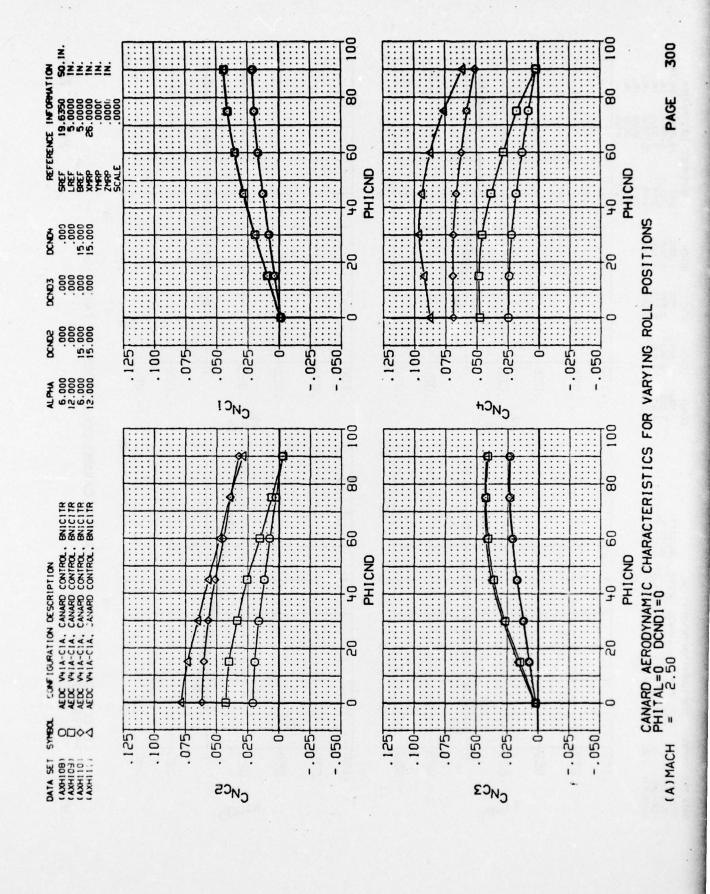


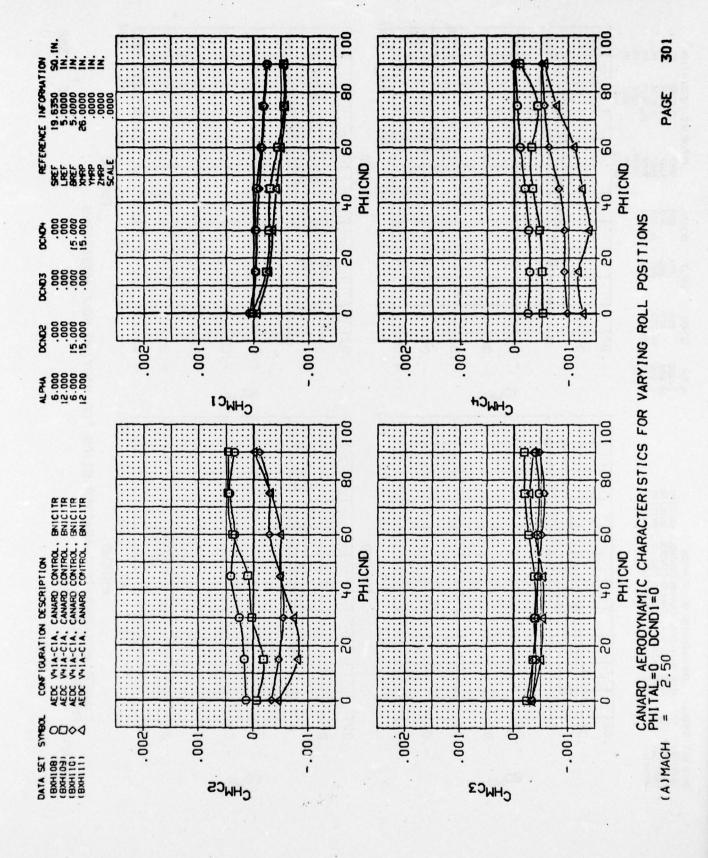


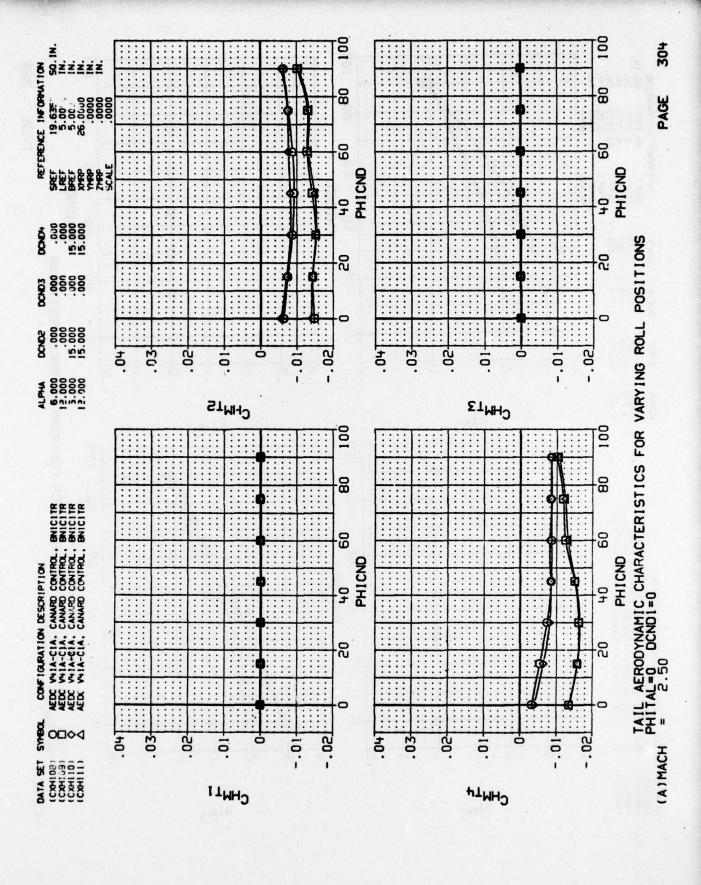


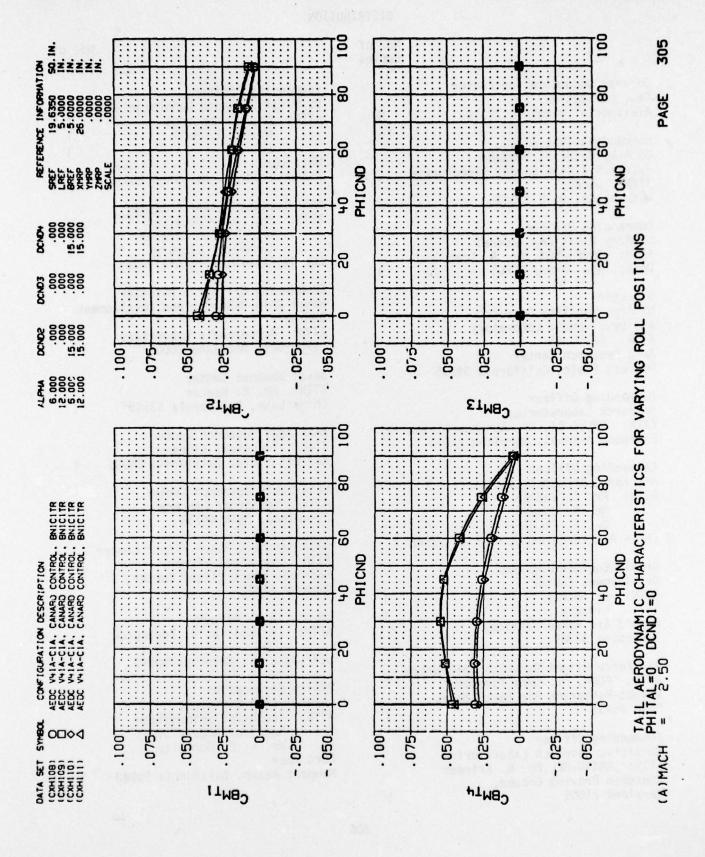
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